
**Local Protection Project
Beaver Brook
Keene, New Hampshire**

Operation and Maintenance Manual

June 1990



**US Army Corps
of Engineers**
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FOR
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BEAVER BROOK
KEENE, NEW HAMPSHIRE**

FOREWORD

The successful functioning of any local flood protection project is not assured solely by the construction of a system of dikes, floodwalls, floodgates, sluice gate structures and other appurtenant structures. If the system is to perform the functions for which it was designed, it must be carefully maintained during normal river stages and properly operated during flood periods.

The purpose of this manual is to provide information regarding actual maintenance procedures and outline the responsibilities of the parties involved. In general, the regulations designate non-Federal interests as having responsibility for operation and maintenance of the project. Therefore, the State of New Hampshire should assure that several local individuals be familiar with this project and have a thorough understanding of the recommended methods of maintaining the system.

The need for proper maintenance cannot be too highly stressed in view of the fact that large damages may be incurred through operating failure of a critical element during flood periods, caused by deterioration or damage that would have been eliminated by proper maintenance.

Necessary maintenance and proper operation require that responsible local persons have a thorough understanding of the functions of the various units of the system and the recommended methods of maintaining the system and operating it during flood emergencies. It is the purpose of this manual to provide complete information so that all parties may fully understand their responsibilities in maintaining and operating the flood protection system in accordance with the regulations prescribed by the Secretary of the Army.

The general flood control Regulations for Operation and Maintenance of Flood Control Works quoted herein were approved by the acting Secretary of War on August 9, 1944. Established by the Department of Defense, the improvement of rivers and harbors and other waterways for flood control and other purposes, formerly under jurisdiction of the Secretary of War, became the responsibility of the Secretary of the Army. References herein to the Secretary of War and War Department shall be construed to mean, respectively, the Secretary of the Army and the Department of the Army. Where reference is made to the District Engineer in the Regulations included in this manual, it shall be construed to mean the Division Engineer, New England Division, Corps of Engineers.

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SECTION I - INTRODUCTION

A. PURPOSE

The purpose of this Manual is to present detailed information to be used as a guide in complying with "Flood Control Regulations - Maintenance and Operation of Flood Control Works" as approved by the Acting Secretary of War on 9 August 1944, and published in this Manual as Appendix A.

The regulations are intended to cover all local protection projects (LPP) constructed by the Department of the Army throughout the United States, are general in nature, and obviously cannot give detailed instructions for the maintenance and operation of a specific project. The details set forth in this Manual for maintenance and operation of the Beaver Brook Project are intended to supplement the Army Regulations to ensure maximum protection against floods for which the project was designed. Failure to maintain and operate the project as required by the Regulations and as detailed herein can result in property losses, loss of life and irreparable loss of confidence in the flood protection system by the citizens who have invested their funds on the basis of the protection afforded by the flood control works.

Included in the authorization of the project are conditions specified by the Secretary of War to be met by local interests. One of these conditions is the operation and maintenance of the project after its completion. Under Assurances, dated 27 August 1985, furnished to the Government by the State of New Hampshire, the State agreed to meet these conditions, and in particular, the operation and maintenance of the project after its completion. A copy of the above assurances is included in Appendix B of this Manual.

B. AUTHORIZATION AND LOCATION

Construction of the local protection project at Beaver Brook was authorized by Section 205 of the 1948 Flood Control Act, as amended by Public Law 93-351 (Water Resources Development Act of 1974), adopted 7 March 1974. Specific authority is contained in 1st Endorsement dated 7 January 1975.

This project is situated in the City of Keene which is located in Cheshire County, New Hampshire, about 42 miles west of Manchester, New Hampshire and 15 miles north of the Massachusetts/New Hampshire State Line. Beaver Brook originates to the north of Keene's city limits and drains an area of about 10 square miles. For the purpose of location description, the Beaver Brook flood plain was divided into six reaches, numbered 1 through 6.

Reach 1 extends from the mouth of Beaver Brook, located just east of the Ashuelot River, upstream to the Route 101 bridge (800 feet) and includes mostly commercial and residential properties.

Reach 2 extends about 2,400 feet upstream from the Route 101 bridge to Marlboro Street and is characterized by single family dwellings with a strip of commercial developments along Marlboro Street.

Reach 3 extends from Marlboro Street upstream about 1,400 feet to the railroad bridge, and includes the largest industrial complex in the flood plain (Kingsbury Machine Tool Company).

Reach 4 extends from the railroad bridge upstream about 1,700 feet to Roxbury Street and includes a mixture of commercial, industrial and residential properties, as well as some vacant land.

Reach 5 extends from Roxbury Street upstream about 1,000 feet to Beaver Street and includes a mixture of large single and multi-family homes located on smaller lots.

Reach 6 extends from Beaver Street upstream about 4,000 feet to the upper limit of the urban flood plain around Griffin Street.

Three Mile Swamp is located 3.5 miles upstream of the Beaver Brook confluence with the Ashuelot River.

C. DESCRIPTION OF PROJECT

Structural flood control measures along Beaver Brook in Keene, New Hampshire include a new floodwater retarding structure at the outlet of an upstream wetland called Three Mile Swamp. Also, channel improvements were constructed in the downtown Keene area between Marlboro and Water Streets.

An existing breached stone dam at Three Mile Swamp was replaced by an ungated concrete outlet structure having a stepped spillway which is designed to maintain the existing pool during non-flood periods and utilize additional surcharge storage during a flood event.

Associated with the new outlet structure is a concrete stilling basin and two earthen dikes on the west bank to protect the adjacent Route 10. A 1,750-foot reach of Beaver Brook in downtown Keene was improved to pass flood flows. The channel improvements involved widening the channel bottom, flattening the banks, realigning the brook and installing precast concrete paving blocks on the lower 4 feet of the bank, all of which improve the conveyance of the brook. The channel bottom is flat with a uniform invert elevation 464.5 feet National Geodetic Vertical Datum (NGVD).

D. EFFECTIVENESS OF PROTECTION

1. General. The protective works reduces damages in the Beaver Brook floodplain by creating additional and more effectively utilizing existing flood storage at Three Mile Swamp; and improving flood flow characteristics of Beaver Brook through the high-damage areas.

2. Three Mile Swamp. The new flood retarding structure at Three Mile Swamp has an ungated, stepped concrete spillway with a non-overflow section constructed to elevation 799 feet NGVD. The stepped spillway is designed to maintain the existing pool elevation during non-flood periods and utilize additional surcharge storage during a rise to elevation 797 feet NGVD for a duration of less than 48 hours. The standard project flood (SPF) was adopted as the spillway design flood.

In order to maintain control of floodwaters at the outlet, an earthen dike was constructed along the west bank of the wetland to prevent overflows on Route 10, which parallels the bank. Placement of the outlet structure also involved the construction of a stilling basin downstream of the concrete spillway and tapering of the channel width from the 200-foot spillway width to the existing channel width downstream.

3. Channel Improvements. The channel improvements for Beaver Brook in downtown Keene involved widening the channel and banks to obtain an even slope and width throughout the 1,750-foot long reach whenever possible. The channel width varies from 17 to 26 feet with sides sloped to 1 vertical to 2 horizontal and lined with precast concrete paving blocks to a vertical height of 4 feet above the invert. Within 50 feet of any bridges, the channel side slopes were lined with paving blocks to the top of the banks. Grasses were planted on the upper bank for stabilization. Two bridge abutments were constructed along with two precast modular retaining walls. The railroad bridge decks and railroad abutments were removed. The channel improvements were designed for a streamflow of about 600 cubic feet per second (cfs) which conforms to other unimproved sections of the overall channel. These improvements provide stage reductions principally for the 10-year to 20-year frequency floods.

E. CONSTRUCTION HISTORY

The construction of the Beaver Brook local protection project was initiated in October 1985 and completed in June 1987 by Bridge Construction Company of Augusta, Maine. The Federal cost of the project was approximately \$ 1,900,000.

F. PLANS

Plans pertinent to the operation and maintenance of the project are included for reference in Appendix F in this Manual. The original drawings, corrected to indicate "as-built" construction, have been forwarded to the City of Keene for their retention.

G. LOCAL COOPERATION

The authorizing legislation for the Beaver Brook Local Protection Project was Section 205 of the Flood Control Act of 30 June 1948 (Public Law 858, 80th Congress). As required under this authority, the legally empowered local sponsor (State of New Hampshire) provided the following assurances of local cooperation.

1. Provide without cost to the United States, all lands, easements, rights-of-way, and utility relocations necessary for project construction.
2. Hold and save the United States free from damages due to the construction, operation and maintenance of the project, except where such damages are due to the fault or negligence of the United States or its contractors.
3. Maintain and operate the project after completion without cost to the United States in accordance with regulations prescribed by the Secretary of the Army.
4. Assume the responsibility for all costs in excess of the Federal cost limitation of \$4,000,000.
5. Prevent future encroachment which might interfere with proper functioning of the project.
6. Comply with Title VI of the Civil Rights Act of 1964 (78th Stat. 241) and Department of Defense directive 5500.11 issued pursuant to and published in Part 300 of Title 32, Code of Federal Regulations.
7. Comply with requirements of non-Federal cooperation specified in Sections 210 and 205 of Public Law 91-646 approved 2 January 1971, entitled: Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970.

The formal assurances of the State of New Hampshire are contained in Appendix B of this Manual.

H. GENERAL RULES AND REGULATIONS

Paragraph 208.10 (a) of the regulations prescribed by the Secretary of War gives general rules for the maintenance and operation of structures and facilities constructed by the United States for local flood protection. Applicable portions are quoted below to avoid the necessity for cross reference and are further defined by remarks under each quotation.

"(1) The structures and facilities constructed by the United States for local flood protection shall be continuously maintained in such a manner and operated at such times and for such periods as may be necessary to obtain the maximum benefits."

These requirements cannot be overstressed. City authorities must make adequate provisions for funds, personnel, equipment and materials to allow for the proper maintenance and operation of the flood protective works.

"(2) Unless reciprocal agreements have been made with other entities, the State, political subdivision thereof, or other responsible local agency, which furnished assurance that it will maintain and operate flood control works in

accordance with regulations prescribed by the Secretary of War, as required by law, shall appoint a permanent committee consisting of or headed by an official hereinafter called the 'Superintendent', who shall be responsible for the development and maintenance of, and directly in charge of, an organization responsible for the efficient operation and maintenance of all of the structures and facilities during flood periods and for continuous inspection and maintenance of the project works during the periods of low water, all without cost to the United States."

The committee shall be composed of competent members, preferably persons experienced in engineering or construction works of a similiar nature to the flood protection works. The committee must be given broad authority to carry out its responsibilities. The name, address, and office and home telephone numbers of the Superintendent, and any changes thereof, shall be furnished to the Division Engineer.

"(3) A reserve supply of materials needed during a flood emergency shall be kept on hand at all times."

Sufficient sand bags and sand should be held in reserve to close off Route 10 during extreme flood periods and in case it is necessary to stop leaks through the dikes and to control sand boils and seepage on the protected side of the dikes.

"(4) No encroachment or trespass which will adversely affect the efficient operation or maintenance of the project works shall be permitted upon the rights-of-way for the protective facilities."

The disposal of rubbish, erection of fences, or barriers, the painting or erection of signs, the attachment of clothes lines to flood walls, or any form of trespassing on the project shall be prohibited.

"(5) No improvement shall be passed over, under, or through the walls, dikes, improved channels or floodways, nor shall any excavation or construction be permitted within the limits of the project rights-of-way, nor shall any changes be made in any feature of the works without prior determination by the Division Engineer or his authorized representatives that such improvement, excavation, construction or alteration will not adversely affect the functioning of the protective facilities. Such improvements or alterations as may be found to be desirable and permissible under the above determination shall be constructed in accordance with standard engineering practice. Advice regarding the effect of proposed improvements or alterations on the functioning of the project and information concerning methods of construction acceptable under standard engineering practice shall be obtained from the Division Engineer or, if otherwise obtained, shall be submitted for his approval. Drawings or prints showing such improvements or alterations as finally constructed shall be furnished to the Division Engineer after completion of the work."

Any contemplated improvements or alterations as outlined above must be submitted to the Corps of Engineers, Waltham, Massachusetts, and the approval of the Division Engineer obtained prior to the City authorizing the work. All requests for approval shall be in writing and complete drawings in duplicate, one set of which shall be in reproducible form, must be submitted along with a full description of the work intended. The City will be held responsible for obtaining prior approval from the Corps of Engineers for any improvements or alterations proposed by itself, private parties or any public parties. The City shall furnish the Division Engineer as-built drawings, in duplicate, of the completed work.

"(6) It shall be the duty of the Superintendent to submit a semi-annual report to the Division Engineer covering inspection, maintenance and operation of the protective works."

See paragraph I-K of this Manual for instruction on submitting reports.

"(7) The Division Engineer or his authorized representatives shall have access at all times to all portions of the protective works. The Division Engineer or his representatives will make periodic inspections of the protective works to determine if the project is being properly maintained and operated by the City. Follow-up inspections when necessary, will be made to determine if deficiencies observed during the inspection have been corrected. A report with the results of each inspection will be furnished to the City for appropriate action."

"(8) Maintenance measures or repairs which the Division Engineer deems necessary shall be promptly taken or made."

The City should maintain the facilities and keep them in good repair and not wait for the Division Engineer to call such matters to its attention. Upon request, the Division Office will advise the City how to make any major repairs to the facilities.

"(9) Appropriate measures shall be taken by local authorities to ensure that the activities of all local organizations operating public or private facilities connected with the protective works are coordinated with those of the Superintendent's organization during flood periods."

The local authorities should formulate plans and negotiate agreements with local organizations and companies, who are operating facilities connected with the protective works, to ensure that their activities will be properly coordinated with the Superintendent's organization during flood periods.

"(10) The Corps of Engineers with this document has furnished local interests with an Operation and Maintenance Manual for the completed project to assist them in carrying out their obligations under these regulations."

The flood control committee should familiarize itself with the contents of this manual. Local authorities are encouraged to call on the Division Office of the Corps of Engineers for any additional advice or instructions required by them in carrying out the City's obligations for maintaining and operating the flood protection facilities.

I. MAINTENANCE

The word "maintenance" as used in this manual applies to the upkeep, repair and care of the work constructed by the United States and turned over to the City of Keene, New Hampshire. If the work is neglected there will be deterioration and possible failure in flood time when there is dire need of dependable protection.

Satisfactory and dependable operation depends on constant maintenance. The organization that performs maintenance must be familiar with various parts of the system and will be in a position to use them effectively in time of stress.

Maintenance includes regular inspection of the entire system. The purpose of an inspection is to detect any deterioration or faulty operation that indicates a need for repair or replacement. It should include several walking tours over every part of the system during the course of a year.

J. OPERATION

Operation in this manual refers to the actual use of the various features of the protection works during flood periods. It is intended that the procedure outlined herein under Appendix B will be sufficient to ensure protection from floods to the design stage. However, advice relative to operation may be obtained at any time from the Operation Division (Tel: (617) 647-8411) of the New England Division Office.

Representatives of the Division Engineer stand ready to assist in the operation of the project. However, this in no way lessens the responsibility of the City in operating the project.

When abnormal river flows and stages are expected, it is important that the Superintendent make immediate decisions and take prompt action and that he have the authority to carry out his decisions.

To ensure correct operation, it is essential that at least two persons: (1) be familiar with all phases of the flood protection works; (2) know just what supplies and transport are on hand; and (3) know what persons and tools can be mobilized for the patrolling and repair work.

It will be to the advantage of the local authorities to negotiate agreements with private owners and companies to operate and maintain project features that are directly related to facilities and property of those parties. However, the Corps of Engineers will look to the City for maintenance and operation of the project since the City of Keene executed reciprocal assurances of local cooperation with the State of New Hampshire.

K. INSPECTION AND REPORTS

The regulations prescribed by the Secretary of the Army call for semi-annual reports to be submitted by the Superintendent to the Division Engineer, covering inspection and maintenance. Inspection of the flood protective facilities shall be made immediately prior to flood seasons, immediately following floods, and otherwise at intervals not exceeding 90 days as required by the regulations.

To assist the Superintendent in making his inspections and reports, sample check list forms including blank NED Form 513 have been prepared and included in Appendix C. The Superintendent shall have additional copies printed for use in submitting his reports.

The semi-annual reports shall be submitted in triplicate to the Division Engineer, ATTN: Operations Branch, Operations Division, each April and October. The reports will be submitted in letter form with copies of the inspection forms covering the inspections made during the period of the report. The reports shall cover the following points:

- A description of the maintenance work.
- The number and classification of persons working on maintenance regularly and intermittently.
- Description of any work performed by contract on the repair or improvement of the project.
- Description of use or operation of the system during the period being reported.
- Suggestions relative to public cooperation and comments concerning public sentiment on the protection obtained are considered pertinent and desirable data for inclusion in the project, but such data are not required.

II. CHANNEL IMPROVEMENT

A. DESCRIPTION

Channel modification of Beaver Brook in the 1,750-foot reach between Marlboro and Water Streets included construction of the retaining walls and a trapezoidal channel with an average depth of 7 feet and a bottom width varying from 17 to 26 feet. The lower 4 feet of the channel, which slopes at 1 vertical and 2 horizontal, were protected with precast concrete paving blocks and the upper 3 feet were seeded with flood tolerant grasses where ever existing walls do not exist. The bottom of the channel is unlined and is flat. Within 50 feet of all bridges, the slopes were lined with precast concrete paving blocks to the top of the banks.

B. MAINTENANCE

Paragraph 208.10(g)(1) of the prescribed regulations sets forth rules for the maintenance of channels and floodways. These rules are quoted below, followed by brief comments on the particular applicability of these rules to the project.

"Channels and Floodways

(1) Maintenance. Periodic inspections of improved channels and floodways shall be made by the Superintendent to be certain that:

(i) The channel or floodway is clear of debris, weeds, and wild growth."

All debris and growth which tend to restrict the channel shall be removed promptly.

"(ii) The channel or floodway is not being restricted by the depositing of waste materials, building of unauthorized structures or other encroachments."

Dumping of waste materials or any types of encroachment on the channel shall be prohibited and prompt steps shall be taken to remove or have removed any such encroachments.

"(iii) The capacity of the channel or floodway is not being reduced by the formation of shoals."

Shoal areas should be removed but care should be exercised that the slopes of the channel and existing banks are not undercut. Existence of shoal areas will be apparent from inspections during time of low flow.

"(iv) Banks are not being damaged by rain or wave wash, and that no sloughing of banks has occurred."

Banks damaged by rain, wave wash, or sloughing shall be repaired promptly, using bankrun gravel and precast concrete paving blocks similar to that used in the original construction. Banks should be inspected to determine if they are being damaged or eroded by natural forces or by forces such as vehicles or by vandals.

"(v) Approach and egress channels adjacent to the improved channel or floodway are sufficiently clear of obstructions and debris to permit proper functioning of the project works."

In order for this project to function properly and as designed, the improved channel sections between the outlet structure and the mouth of Beaver Brook must be maintained in such condition that they are capable of carrying flood flows and will not cause Beaver Brook to back-up, thus nullifying the effect of the improved channel sections.

"Such inspection shall be made prior to the beginning of the flood season and otherwise at intervals not to exceed 90 days. Immediate steps will be taken to remedy any adverse conditions disclosed by such inspections. Measures will be taken by the Superintendent to promote the growth of grass on the bank slopes and...dikes. The Superintendent shall provide for periodic repair and cleaning of debris...as may be necessary."

Maintenance should also include the inspection, maintenance, and repair or replacement of the chainlink fencing, guard rails, concrete bridge abutments, concrete retaining walls, and precast concrete paving blocks.

C. OPERATION

Paragraph 208.10(g)(2) of the prescribed regulations gives rules for operation of channels and floodways. These rules which are quoted below are self-explanatory and require no amplification with regard to the project.

"(2) Operation. Both banks of the channels shall be patrolled during periods of high water, and measures shall be taken to protect those reaches being attacked by the current or by wave wash. Appropriate measures shall be taken to prevent the formation of jams of ice or debris. Large objects which become lodged against the banks, bridge abutments and culverts shall be removed. The improved channel or floodway shall be thoroughly inspected immediately following each major high water period. As soon as practicable thereafter, all snags and other debris shall be removed and all damage to banks...dikes and walls, drainage outlets, or other flood control structures repaired."

III. DIKES

A. DESCRIPTION

Two dikes were built one parallel to and the other perpendicular to Route 10, to divert and contain Standard Project Flood (SPF) levels at Three Mile Swamp.

(1) Dike A, which is parallel to Route 10, is approximately 1,100 feet long and varies in height from 7 feet at the dam to 2 feet about 1,100 feet upstream of the dam. The top of the dike is 12 feet wide at elevation 799 feet NGVD providing 2 feet of freeboard above the SPF pool elevation of 797 feet NGVD. The side slopes are 1 vertical on 2 horizontal. The dike is constructed of compacted gravel and impervious fill. On the wetland side of the dike, the slope is protected by a 2-foot thick layer of stone protection placed on 1-foot layer of gravel bedding, while the landside slope of the dike is topsoiled and seeded.

(2) Dike B which is actually a continuation of Dike A but on the opposite side of Route 10, is perpendicular to Route 10. Dike B has a maximum height of 8 feet with a top elevation of 799.0 feet NGVD, and is about 185 feet long. The top is 12 feet wide with side slopes at 1 vertical on 2.5 horizontal. The dike is constructed of compacted random fill and dumped gravel fill and is covered with a 6 inch layer of topsoil and seeded to prevent erosion.

B. MAINTENANCE

Paragraph 208.10(b)(1) of the prescribed regulations sets forth rules for the maintenance of levees (earthen dikes) and dams. Applicable portions are quoted below:

"Dikes. (1) Maintenance. The Superintendent shall provide at all times such maintenance as may be required to insure serviceability of the structures in time of flood. Measures shall be taken to provide the growth of sod, to exterminate burrowing animals, and to provide for routine mowing of the grass and weeds, removal of wild growth and drift deposits, and repair of damage caused by erosion or other forces. Periodic inspections shall be made by the Superintendent to insure that the above maintenance measures are being effectively carried out and, further, to be certain that:

(a) No unusual settlement, sloughing or material loss of grade or levee cross section has taken place;

(b) No caving has occurred on either side of the levee which might affect the stability of the levee section;

(c) No seepage, saturated areas, or sand boils are occurring;

(d) No action is being taken, such as burning grass and weeds during inappropriate seasons, which will retard or destroy the growth of sod."

Such inspections shall be made immediately prior to the beginning of the flood season; immediately following each major high water period, and otherwise at intervals not exceeding 90 days; and such intermediate times as may be necessary to insure the best possible care of the levee. Immediate steps will be taken to correct dangerous conditions disclosed by such inspections. Regular maintenance repair measures shall be accomplished during the appropriate season as scheduled by the Superintendent."

Any unusual settlement, sloughing or caving should be corrected to restore the original dike grades. No major repair work shall be made without prior approval of the Division Engineer, in order that such repairs that may be necessary will not adversely affect the functioning of the protective facilities.

The slopes of dikes, and portions of the slopes of the outlet structure abutments were topsoiled and seeded to minimize the damage from erosion and scour caused by surface runoff. Maintenance of a sturdy sod growth on these embankments is highly important as sod is one of the most cost effective means of protecting the levee against erosion. Periodic mowing is essential to maintaining a good sod growth, and should be done at such intervals as necessary to keep down weeds and other noxious growth and to prevent the grass height from exceeding 12 inches.

When sections of the dikes or outlet structure require reestablishment of turf, seeding operations should be started at the earliest practicable date in the spring to secure the greatest possible protection against erosion. Areas requiring seeding shall be dressed to fill gullies and irregularities in the surface. The following seed mixture was used in the original construction:

TABLE 1
GRASS SEED

<u>KIND OF SEED</u>	<u>% BY WEIGHT PROPORTION</u>	<u>GERMINATION MINIMUM %</u>	<u>PURITY MINIMUM %</u>
Red Fescue	30%	80%	87%
Chewings Fescue	30%	80%	97%
Kentucky Bluegrass	30%	80%	85%
Perennial Ryegrass	10%	90%	98%

C. EMERGENCY REPAIR MEASURES

1. Scours:

Careful watch of the dike for indication of scouring should be emphasized. If any indication of scouring is observed, soundings should be taken to observe the amount and progress of the scour. Sandbagging or dumped rock will generally afford the most practicable means of combating this condition. The open ends of sandbags so used must be sewed or tied after filling.

2. Sand Boils:

a. General. A sand boil is the result of a transfer of pressure head and seepage from the river, through a pervious stratum near or at the surface, to the landside of the dike.

This seepage underpressure tends to push its way to the surface and actually floats the material through which it flows. No harmful effect results, provided the weight of the relatively impervious soil layer overlying the pervious stratum, in which the flow under pressure is occurring, is sufficient to counterbalance this pressure. When the soil stream overlying the pervious layer is insufficient to counterbalance the upward pressure or when no such stratum exists, boils break through the surface on the landside wherever these weaknesses are present. The sand boil may discharge relatively clear water or the discharge may contain quantities of sand and silt, depending upon the magnitude of the pressure and the size of the boil.

b. Effects of Sand Boils. Sand boils can produce three distinctly different effects on the levee, depending upon the condition of flow under the levee. These three effects are illustrated in Appendix E. In Figure 1, Plate No. I, the seepage flow develops a definite pipe or tube under the levee. This breaks out at the landside toe in the form of one or more large sand boils. Unless checked, this flow causes a cavern to be developed under the levee, resulting in subsidence of the levee and subsequent overtopping. This case can be most easily recognized by slumping of the levee crown. Figure 2, Plate No. I of Appendix E, illustrates the case where seepage flows under pressure under the levee without following a defined path, as in the case above. This flow results in one or more boils outcropping at or near the landside toe. The flow from these boils tends to undercut and ravel the slope, resulting in sloughing of the slope. Evidence of this type of failure is found in undercutting and ravelling at the landside toe. Figure 3, Plate No. I of Appendix E, shows a third type of effect of a sand boil. In this case, numerous small boils, many of which are scarcely noticeable, outcrop at or near the toe. While no boil may appear to be dangerous in itself, the consequence of the group of boils is to cause floatation of the soil, thereby reducing the shearing strength of the material at the toe, where maximum shearing stress occurs, to such an extent that failure of the slope through sliding results.

c. General Instructions for Handling Sand Boils. All sand boils shall be watched closely. A sand boil which discharges clear water in a steady flow is usually not dangerous to the safety of the dike. However, if the flow of water increases and the sand boil begins to discharge material, corrective action shall be taken immediately.

d. Method of Treatment.

(1) The accepted method of treating sand boils is to construct a ring of sandbags around the boil, building up a head of water within the ring sufficient to prevent further movement of sand and silt. The accepted method of ringing a sand boil, shown on Plate No. II of Appendix E is as follows:

(a) The entire base of the sack ring is cleared of debris in order to provide a watertight bond between the natural ground and the sack ring.

(b) The sacks are then laid in a ring around the boil, with joints staggered, and with loose earth between all sacks.

(c) The ring is carried only to a height sufficient to prevent material from being discharged. The ring should not entirely stop the flow of water, because of the probability of the excessive local pressure head causing additional ruptures of impervious strata and bails nearby.

(d) A "V" shaped drain constructed of two boards, or a piece of sheet metal, is then placed near the top of the ring to carry off water.

(2) Actual conditions at each sand boil will determine the exact dimensions of the ring. The diameter and height of the ring depend upon the size of the boil, and the flow of water from it. In general, the following considerations should govern:

(a) The base width should be no less than 1-1/2 times the contemplated height.

(b) It is well to include weak ground near the boil within the ring, thereby preventing a break-through later.

(c) The ring should be of sufficient size to permit sacking operations to keep ahead of the flow of water.

(3) Where many boils are found to exist in a given area, a ring levee of sandbags shall be constructed around the entire area and, if necessary, water pumped into the area to provide sufficient weight to counterbalance the upward pressure.

3. Sloughs:

During prolonged high water stages, seeping and sloughing conditions on the landside slopes may occur. Such conditions should be observed closely as to progress of seepage up the landside slope and the amount of material that is being carried by seepage. If the seep velocity becomes great enough to cause, or probably cause, erosion or sloughing of the slope, a sandbag covering should be placed on the seeping area, beginning well out from the toe and progressing up slope. The covering should extend several feet beyond the saturated area. If the material is obtainable, the affected area should be covered with brush, straw or similar permeable material to a depth of two to four inches before placing the sandbag cover. This will permit the seep water to get away while serving as a filter to prevent loss of earth from the dike. After the covering is placed, close observation should be maintained and additional layers of sandbags placed on the previous ones until the velocity of the seepage is reduced to a point at which the amount of material carried is negligible. Sacking sloughs is illustrated on Plate No. III of Appendix E.

4. Raising Existing Earth Dikes:

In an emergency, time and other conditions permitting, the grade of a dike can be safely raised three feet. The methods most commonly used are outlined in the following:

a. Sandbag Topping. The sack ordinarily used for topping an earth dike shall be a grain or feed type sack (in lieu of canvas or sisal-craft type) which holds 100 pounds of grain. Smaller sacks may be used if feed sacks are not available. Grain sacks, filled with about one cubic foot of earth, weighing about 100 pounds, will provide a unit about six inches high, one-foot wide and two feet in length.

The sacks may be filled at the source of material and hauled to the dike or filled from stockpile or borrow areas at the dike, conditions determining the method employed. The same is true of filling; ie. whether power or hand methods are used.

The open end of the sacks should always face upstream or toward the riverside of the dike and need not be sewed or tied. When the sack faces the river the loose end should be folded under and when facing upstream the loose end covered by the succeeding sack.

The front line of sandbags in the first layer should be laid parallel to the dike center line and remaining bags at right angles to the center line. The sandbags in the second layer are all laid at right angles to the center line, the third row similar to the first, etc., as shown on Plate No. IV of Appendix E. All sacks should be lapped about 1/3 each way and well mauled or tramped into place. The sacks should be filled to two-thirds their capacity when flattened out to facilitate proper placing and prevent bursting the sack when mauled or tramped into place.

Plate No. IV of Appendix E illustrates the progressive method of increasing the dike height and gives an approximation of the number of sacks required for dikes of various heights. Plate No. V of Appendix E shows pictures of model sack dike or topping.

A crew of 50 men should fill, carry and place approximately 1,000 sacks per eight-hour day, all hand labor, when the source of material is within 150 feet of the point of placement. Production will depend on conditions at the site, location of storage and loading areas, and type of bag filling equipment used.

b. Lumber and Sandbag Topping. Lumber and sandbag topping is the most satisfactory method of raising low reaches of earth dike in emergencies. The chief objection is the time required to install. In putting on this topping, as well as any other topping, a careful line of levels should be run and grade stakes set in advance unless the dike top follows a dependable grade line. Two-by-four or two-by-six inch stakes should then be driven on the river side of the crown six feet apart and one-by-twelve inch boards nailed to land side of the stakes. This wall, backed with a single tier of sandbags, will hold out at least one-foot of water. If the second foot is necessary, the layers of bags will have to be increased in number and reinforced. Sandbags are laid substantially in the manner described in paragraphs above.

c. Contingency Measures:

The outlet structure at Three Mile Swamp is a self-regulating spillway with no gateworks that require operation during flood periods. One exception to the absence of an operation requirement is the dike adjacent to Route 10, which provides two feet of freeboard against the stage of the SPF. At the location where the dike intersects Route 10, the surface elevation of the roadway is 2 feet lower than the top of the dike, representing an opening in the freeboard range. If freeboard protection were ever required at this location, the City of Keene would have to sandbag Route 10 to maintain control of flood flows.

IV. STORM DRAINAGE

A. DESCRIPTION

The main storm drainage structure associated with the project is a 42-inch reinforced concrete pipe (Class V) located under Route 10 below the Three Mile Swamp Dam. It has a concrete headwall and Class I pipe bedding.

An underdrain extends along the landside of the dike at Sta. 0+00 to Sta. 11+23 with an outlet below the dam. Approximately 880 feet of RCC pipe is located on the west side of Route 10.

Both Type I and Type II catch basins are located along each side of Route 10 and they are situated on Class II pipe bedding.

B. MAINTENANCE

The lines and drains downstream of the outlet structure should be adequately maintained and any breaks or leaks promptly repaired. Where any excavations are necessary, backfills shall be carefully and thoroughly compacted, taking care no voids or nest of cobbles or gravel are allowed to occur. Paragraph 208.10(d)(1) of the prescribed regulations gives rules for maintenance of drainage structures.

1. "Adequate measures shall be taken to insure that inlet and outlet channels are kept open and that trash, drift, or debris is not allowed to accumulate near drainage structures, including catch basins both inside and outside. Periodic inspections shall be made by the Superintendent to be certain that:
 - (a) Pipes, riprap, and headwalls are in good condition;
 - (b) Inlet and outlet channels are open;
 - (c) Care is being exercised to prevent the accumulation of trash and debris near the structures and that no fires are being built near bituminous coated pipes; and
 - (d) Erosion is not occurring adjacent to the structure which might endanger its water tightness or stability.

Immediate steps will be taken to repair damage, replace missing or broken parts, or remedy adverse conditions disclosed by such inspections."

2. All metal surfaces not otherwise protected must be kept painted to maintain the metal in good condition. The exterior and interior metal work, such as ladders, pipe railings and cover plates, will require frequent painting because of exposure to the weather and or to waters.

V. OUTLET STRUCTURE

A. DESCRIPTION

The outlet structure at Three Mile Swamp is a concrete gravity outlet structure, 292 feet long with a top elevation of 799 feet National Geodetic Vertical Datum (NGVD). The self-regulating spillway has an 9-foot width at elevation 788 feet NGVD, a 40-foot width at elevation 792 feet NGVD, and a 130-foot width at elevation 794 feet NGVD. This spillway configuration stores runoff during flood periods and maintains the existing pond elevation during other periods. A stilling basin was constructed at the downstream toe of the outlet structure to dispel the energy of the spillway discharges. This stilling basin extends along the full 200-foot width of the spillway for a distance 20 feet downstream of the toe, but is interrupted at the first 40-foot section of weir by a 2-foot wide wall. This 40-foot wide stilling basin is at elevation 781.0 feet NGVD, 11 feet below its weir crest elevation. The remaining portion of the stilling basin which is 130 feet long is at elevation 785.0 feet NGVD, 9 feet below its weir crest elevation.

The structure provides storage for 1.6 inches of runoff from the upstream drainage area of 6 square miles and reduces wetland discharges during the estimated 100-year event from 1,730 cfs to 1,170 cfs. Based on hydraulic analysis of the drainage modifying effects of the outlet structure, it is estimated that the structure could reduce downstream river stages by 1 to 1.5 feet during a 10-year flood, with lesser stage reductions during greater flood periods. The improvements at the outlet of Three Mile Swamp should not be viewed as a flood control dam, because these modifications are not designed to eliminate flooding on Beaver Brook. Instead the improvements should be viewed as measures which capitalize on the wetlands effectiveness as a natural flood retention area.

B. MAINTENANCE

1. Outlet Structure.

- (a) Abutments. The slopes of the outlet structure abutments, protected by stone protection, must be carefully watched for settlement or erosion. Slopes shall be kept free of debris and vegetation.

Burrowing animals constitute a hazard to any embankment. Inspect for burrow holes and fill them in.

- (b) WingWalls. In instances where the slopes are confined by a retaining wall, it shall be inspected monthly with inspections progressively increased to daily when the pool level is equal to half the height of the outlet structure (elevation 793.5 NGVD). Any movement, cracks or seepages through or around the wall must be noted, promptly reported, and corrected.

(c) Inspection During Floods. Continually/periodically monitoring the entire Local Protection Project for possible problems during a flood event is of great importance to insure that the Project is fulfilling its intend purpose.

The behavior of the outlet structure during floods is of vital importance. Periods of storage are the times of danger and, if weaknesses develop, it is essential that they be noted and prompt corrective action taken. The Superintendent must recognize that a condition which is of minor importance with a relatively low head may assume serious proportions with increasing pool levels, and he must be constantly alert to note, report, and correct even minor failures or changes in the conditions of the earth abutments. Results of a single, careful inspection of the structure during a flood can be more significant and valuable than a great number of equally careful inspections when the structure is not impounding water.

2. Outlet Works and Spillway.

(a) Concrete. The concrete outlet structure is 292 feet long, with spillway widths of 9 feet at elevation 788.0, 40 feet at elevation 792.0, and 130 feet at elevation 794.0. The total overflow length is 184 feet. The stilling basin is constructed of concrete with a stone apron beyond the stilling basin. The concrete structures shall be carefully inspected at intervals of six months and after each major filling operation. The inspection shall include a survey of the general conditions of the concrete surfaces, noting location and extent of cracks, crazing and spalling, and other types of deterioration or disintegration that may have developed. Surfaces adjacent to cracks shall be inspected for differential movement; similar inspections shall be made of construction and expansion joints. Any point or points of leakage will be noted and the condition of all water passages inspected for evidence of erosion or cavitation. The exposed portion of embedded items and the concrete adjacent thereto shall be carefully inspected. Any condition requiring or suspected to require corrective action shall be brought to the attention of the Division Engineer immediately. The inspection shall be made a matter of record with report submitted to the Division Engineer, including a sketch showing the location and nature of the defects.

(b) Stone Slope Protection. Stone protection shall be kept free from debris and vegetation. Dislodged stones must be promptly replaced.

(c) Grassed Slopes. Monthly inspections shall be made of all grassed slopes and other grassed areas to note subsidence, slides, erosion, etc. All grassed areas shall be mowed at least once a year. On many areas it will be necessary to mow two or more times a year to keep up the appearance and discourage the growth of weeds and brush. When necessary to reestablish turf, the seeding operation will start at the earliest practicable date in the spring or fall to obtain the greatest possible protection against erosion. Areas requiring seeding shall be dressed to proper grade, and irregularities in the surface removed. The surface should then be raked or harrowed parallel to the contour of the slope (never up and down) to a depth of three-quarters of an inch. Debris shall always be removed promptly; deposits are unsightly, detrimental to growth of grass and encourage the nesting of rats and other burrowing animals.

(d) Baffle Blocks. When the flow through the baffle blocks is at a minimum in the summer, baffle blocks shall be inspected as required. All debris collecting at the blocks shall be removed from the site.

(e) Stop Log Structures. The purpose of the stop log structure is to vary the elevation of the water at the upstream side of the dam. They should be inspected periodically for evidences of rot or breakage. Logs in a damaged or deteriorated state must be replaced to restore full strength to the structure. The upstream side of the stop log structure shall be kept free of all branches, brush or elements that impede the normal flow.

(f) Fences. When necessary fences will be touched-up by galvanizing.

3. Access Roads.

(a) Surfacing. Roads will be repaired periodically with the type of wearing surface with which roads were originally constructed. The Superintendent will be responsible for keeping surfaces maintained.

(b) Slopes. Slopes will be kept in a well-maintained condition as outlined under 2(c).

4. Reservoir Area.

(a) Removal of Dead and Down Timber. The reservoir area, particularly in the lower levels, will be kept cleared of all down and dead timber.

VI. OPERATIONS PLAN

(a) Project Operations. A considered and practiced plan of project operation and maintenance should be in readiness at all times. Severe floods can occur at any time of the year. However, there is usually a limited period of warning in which to mobilize men and equipment for serious flood conditions.

(b) Cooperation. Representatives of the Division Engineer stand ready to assist the City in the operation of the project. This in no way lessens the responsibility of the City of Keene in operating the project.

VII. DRAWINGS AND SPECIFICATIONS

A full sized set of plans showing the project as actually constructed will be furnished to the City of Keene at the time of completion and transmittal of this manual; reduced prints of these drawings pertinent to the operations and maintenance of the project are included for reference in Appendix F.

APPENDIX A

**REGULATIONS PRESCRIBED BY THE
SECRETARY OF THE ARMY**

TITLE 33—NAVIGATION AND NAVIGABLE WATERS

Chapter II—Corps of Engineers, War Department

PART 208—FLOOD CONTROL REGULATIONS MAINTENANCE AND OPERATION OF FLOOD CONTROL WORKS

Pursuant to the provisions of section 3 of the Act of Congress approved June 22, 1936, as amended and supplemented (49 Stat. 1571; 50 Stat. 877; and 55 Stat. 638; 33 U. S. C. 701c; 701c-1), the following regulations are hereby prescribed to govern the maintenance and operation of flood control works:

§ 208.10 *Local flood protection works; maintenance and operation of structures and facilities*—(a) *General.* (1) The structures and facilities constructed by the United States for local flood protection shall be continuously maintained in such a manner and operated at such times and for such periods as may be necessary to obtain the maximum benefits.

(2) The State, political subdivision thereof, or other responsible local agency, which furnished assurance that it will maintain and operate flood control works in accordance with regulations prescribed by the Secretary of War, as required by law, shall appoint a permanent committee consisting of or headed by an official hereinafter called the "Superintendent," who shall be responsible for the development and maintenance of, and directly in charge of, an organization responsible for the efficient operation and maintenance of all of the structures and facilities during flood periods and for continuous inspection and maintenance of the project works during periods of low water, all without cost to the United States.

(3) A reserve supply of materials needed during a flood emergency shall be kept on hand at all times.

(4) No encroachment or trespass which will adversely affect the efficient operation or maintenance of the project works shall be permitted upon the right-of-way for the protective facilities.

(5) No improvement shall be passed over, under, or through the walls, levees, improved channels or floodways, nor shall any excavation or construction be permitted within the limits of the project right-of-way, nor shall any change be made in any feature of the works without prior determination by the District Engineer of the War Department or his authorized representative that such improvement, excavation, construction, or alteration will not adversely affect the functioning of the protective facilities. Such improvements or alterations as may be found to be desirable and permissible under the above determination shall be constructed in accordance with standard engineering practice. Advice regarding the effect of proposed improvements or alterations on the functioning of the project and information concerning methods of construction acceptable under standard engineering practice shall be obtained from the District Engineer or, if otherwise obtained, shall be submitted for his approval. Drawings or prints showing such improvements or alterations as finally constructed shall be furnished the District Engineer after completion of the work.

(6) It shall be the duty of the superintendent to submit a semiannual report to the District Engineer covering inspection, maintenance, and operation of the protective works.

(7) The District Engineer or his authorized representatives shall have access at all times to all portions of the protective works.

(8) Maintenance measures or repairs which the District Engineer deems necessary shall be promptly taken or made.

(9) Appropriate measures shall be taken by local authorities to insure that the activities of all local organizations operating public or private facilities connected with the protective works are coordinated with those of the Superintendent's organization during flood periods.

(10) The War Department will furnish local interests with an Operation and Maintenance Manual for each completed project, or separate useful part thereof, to assist them in carrying out their obligations under these regulations.

(b) *Levees*—(1) *Maintenance.* The Superintendent shall provide at all times such maintenance as may be required to insure serviceability of the structures in time of flood. Measures shall be taken to promote the growth of sod, exterminate burrowing animals, and to provide for routine mowing of the grass and weeds, removal of wild growth and drift deposits, and repair of damage caused by erosion or other forces. Where practicable, measures shall be taken to retard bank erosion by planting of willows or other suitable growth on areas riverward of the levees. Periodic inspections shall be made by the Superintendent to insure that the above maintenance measures are being effectively carried out and, further, to be certain that:

(i) No unusual settlement, sloughing, or material loss of grade or levee cross section has taken place;

(ii) No caving has occurred on either the land side or the river side of the levee which might affect the stability of the levee section;

(iii) No seepage, saturated areas, or sand boils are occurring;

(iv) Toe drainage systems and pressure relief wells are in good working condition, and that such facilities are not becoming clogged;

(v) Drains through the levees and gates on said drains are in good working condition;

(vi) No revetment work or riprap has been displaced, washed out, or removed;

(vii) No action is being taken, such as burning grass and weeds during inappropriate seasons, which will retard or destroy the growth of sod;

(viii) Access roads to and on the levee are being properly maintained;

(ix) Cattle guards and gates are in good condition;

(x) Crown of levee is shaped so as to drain readily, and roadway thereon, if any, is well shaped and maintained;

(xi) There is no unauthorized grazing or vehicular traffic on the levees;

(xii) Encroachments are not being made on the levee right-of-way which might endanger the structure or hinder its proper and efficient functioning during times of emergency.

Such inspections shall be made immediately prior to the beginning of the flood season; immediately following each major high water period, and otherwise at intervals not exceeding 90 days, and such intermediate times as may be necessary to insure the best possible care of

the levee. Immediate steps will be taken to correct dangerous conditions disclosed by such inspections. Regular maintenance repair measures shall be accomplished during the appropriate season as scheduled by the Superintendent.

(2) *Operation.* During flood periods the levee shall be patrolled continuously to locate possible sand boils or unusual wetness of the landward slope and to be certain that:

(i) There are no indications of slides or sloughs developing;

(ii) Wave wash or scouring action is not occurring;

(iii) No low reaches of levee exist which may be overtopped;

(iv) No other conditions exist which might endanger the structure.

Appropriate advance measures will be taken to insure the availability of adequate labor and materials to meet all contingencies. Immediate steps will be taken to control any condition which endangers the levee and to repair the damaged section.

(c) *Flood walls.*—(1) *Maintenance.* Periodic inspections shall be made by the Superintendent to be certain that:

(i) No seepage, saturated areas, or sand boils are occurring;

(ii) No undue settlement has occurred which affects the stability of the wall or its water tightness;

(iii) No trees exist, the roots of which might extend under the wall and offer accelerated seepage paths;

(iv) The concrete has not undergone cracking, chipping, or breaking to an extent which might affect the stability of the wall or its water tightness;

(v) There are no encroachments upon the right-of-way which might endanger the structure or hinder its functioning in time of flood;

(vi) Care is being exercised to prevent accumulation of trash and debris adjacent to walls, and to insure that no fires are being built near them;

(vii) No bank caving conditions exist riverward of the wall which might endanger its stability;

(viii) Toe drainage systems and pressure relief wells are in good working condition, and that such facilities are not becoming clogged.

Such inspections shall be made immediately prior to the beginning of the flood season, immediately following each major high water period, and otherwise at intervals not exceeding 90 days. Measures to eliminate encroachments and effect repairs found necessary by such inspections shall be undertaken immediately. All repairs shall be accomplished by methods acceptable in standard engineering practice.

(2) *Operation.* Continuous patrol of the wall shall be maintained during flood periods to locate possible leakage at monolith joints or seepage underneath the wall. Floating plant or boats will not be allowed to lie against or tie up to the wall. Should it become necessary during a flood emergency to pass anchor cables over the wall, adequate measures shall be taken to protect the concrete and construction joints. Immediate steps shall be taken to correct any condition which endangers the stability of the wall.

(d) *Drainage structures.*—(1) *Maintenance.* Adequate measures shall be taken to insure that inlet and outlet channels are kept open and that trash, drift, or debris is not allowed to accumulate near drainage structures. Flap gates and manually operated gates and valves on

drainage structures shall be examined, oiled, and trial operated at least once every 90 days. Where drainage structures are provided with stop log or other emergency closures, the condition of the equipment and its housing shall be inspected regularly and a trial installation of the emergency closure shall be made at least once each year. Periodic inspections shall be made by the Superintendent to be certain that:

(i) Pipes, gates, operating mechanism, riprap, and headwalls are in good condition;

(ii) Inlet and outlet channels are open;

(iii) Care is being exercised to prevent the accumulation of trash and debris near the structures and that no fires are being built near bituminous coated pipes;

(iv) Erosion is not occurring adjacent to the structure which might endanger its water tightness or stability.

Immediate steps will be taken to repair damage, replace missing or broken parts, or remedy adverse conditions disclosed by such inspections.

(2) Operation. Whenever high water conditions impend, all gates will be inspected a short time before water reaches the invert of the pipe and any object which might prevent closure of the gate shall be removed. Automatic gates shall be closely observed until it has been ascertained that they are securely closed. Manually operated gates and valves shall be closed as necessary to prevent inflow of flood water. All drainage structures in levees shall be inspected frequently during floods to ascertain whether seepage is taking place along the lines of their contact with the embankment. Immediate steps shall be taken to correct any adverse condition.

(c) Closure structures—(1) Maintenance. Closure structures for traffic openings shall be inspected by the superintendent every 90 days to be certain that:

(i) No parts are missing;

(ii) Metal parts are adequately covered with paint;

(iii) All movable parts are in satisfactory working order.

(iv) Proper closure can be made promptly when necessary;

(v) Sufficient materials are on hand for the erection of sand bag closures and that the location of such materials will be readily accessible in times of emergency.

Tools and parts shall not be removed for other use. Trial erections of one or more closure structures shall be made once each year, alternating the structures chosen so that each gate will be erected at least once in each 3-year period. Trial erection of all closure structures shall be made whenever a change is made in key operating personnel. Where railroad operation makes trial erection of a closure structure infeasible, rigorous inspection and drill of operating personnel may be substituted therefor. Trial erection of sand bag closures is not required. Closure materials will be carefully checked prior to and following flood periods, and damaged or missing parts shall be repaired or replaced immediately.

(2) Operation. Erection of each movable closure shall be started in sufficient time to permit completion before flood waters reach the top of the structure sill. Information regarding the proper method of erecting each individual closure structure, together with an estimate of the time required by an experienced crew to complete its erection will be given

in the Operation and Maintenance Manual which will be furnished local interests upon completion of the project. Closure structures will be inspected frequently during flood periods to ascertain that no undue leakage is occurring and that drains provided to care for ordinary leakage are functioning properly. Boats or floating plant shall not be allowed to tie up to closure structures or to discharge passengers or cargo over them.

(f) Pumping plants—(1) Maintenance. Pumping plants shall be inspected by the Superintendent at intervals not to exceed 30 days during flood seasons and 90 days during off-flood seasons to insure that all equipment is in order for instant use. At regular intervals, proper measures shall be taken to provide for cleaning plant, buildings, and equipment, repainting as necessary, and lubricating all machinery. Adequate supplies of lubricants for all types of machines, fuel for gasoline or diesel powered equipment, and flash lights or lanterns for emergency lighting shall be kept on hand at all times. Telephone service shall be maintained at pumping plants. All equipment, including switch gear, transformers, motors, pumps, valves, and gates shall be trial operated and checked at least once every 90 days. Megger tests of all insulation shall be made whenever wiring has been subjected to undue dampness and otherwise at intervals not to exceed one year. A record shall be kept showing the results of such tests. Wiring disclosed to be in an unsatisfactory condition by such tests shall be brought to a satisfactory condition or shall be promptly replaced. Diesel and gasoline engines shall be started at such intervals and allowed to run for such length of time as may be necessary to insure their serviceability in times of emergency. Only skilled electricians and mechanics shall be employed on tests and repairs. Operating personnel for the plant shall be present during tests. Any equipment removed from the station for repair or replacement shall be returned or replaced as soon as practicable and shall be trial operated after reinstallation. Repairs requiring removal of equipment from the plant shall be made during off-flood seasons insofar as practicable.

(2) Operation. Competent operators shall be on duty at pumping plants whenever it appears that necessity for pump operation is imminent. The operator shall thoroughly inspect, trial operate, and place in readiness all plant equipment. The operator shall be familiar with the equipment manufacturers' instructions and drawings and with the "Operating Instructions" for each station. The equipment shall be operated in accordance with the above-mentioned "Operating Instructions" and care shall be exercised that proper lubrication is being supplied all equipment, and that no overheating, undue vibration or noise is occurring. Immediately upon final recession of flood waters, the pumping station shall be thoroughly cleaned, pump house sumps flushed, and equipment thoroughly inspected, oiled and greased. A record or log of pumping plant operation shall be kept for each station, a copy of which shall be furnished the District Engineer following each flood.

(g) Channels and floodways—(1) Maintenance. Periodic inspections of improved channels and floodways shall be made by the Superintendent to be certain that:

(i) The channel or floodway is clear of debris, weeds, and wild growth;

(ii) The channel or floodway is not being restricted by the depositing of waste materials, building of unauthorized structures or other encroachments;

(iii) The capacity of the channel or floodway is not being reduced by the formation of shoals;

(iv) Banks are not being damaged by rain or wave wash, and that no sloughing of banks has occurred;

(v) Riprap sections and deflection dikes and walls are in good condition;

(vi) Approach and egress channels adjacent to the improved channel or floodway are sufficiently clear of obstructions and debris to permit proper functioning of the project works.

Such inspections shall be made prior to the beginning of the flood season and otherwise at intervals not to exceed 90 days. Immediate steps will be taken to remedy any adverse conditions disclosed by such inspections. Measures will be taken by the Superintendent to promote the growth of grass on bank slopes and earth deflection dikes. The Superintendent shall provide for periodic repair and cleaning of debris basins, check dams, and related structures as may be necessary.

(2) Operation. Both banks of the channel shall be patrolled during periods of high water, and measures shall be taken to protect those reaches being attacked by the current or by wave wash. Appropriate measures shall be taken to prevent the formation of jams of ice or debris. Large objects which become lodged against the bank shall be removed. The improved channel or floodway shall be thoroughly inspected immediately following each major high water period. As soon as practicable thereafter, all snags and other debris shall be removed and all damage to banks, riprap, deflection dikes and walls, drainage outlets, or other flood control structures repaired.

(h) Miscellaneous facilities—(1) Maintenance. Miscellaneous structures and facilities constructed as a part of the protective works and other structures and facilities which function as a part of, or affect the efficient functioning of the protective works, shall be periodically inspected by the Superintendent and appropriate maintenance measures taken. Damaged or unserviceable parts shall be repaired or replaced without delay. Areas used for ponding in connection with pumping plants or for temporary storage of interior run-off during flood periods shall not be allowed to become filled with silt, debris, or dumped material. The Superintendent shall take proper steps to prevent restriction of bridge openings and, where practicable, shall provide for temporary raising during floods of bridges which restrict channel capacities during high flows.

(2) Operation. Miscellaneous facilities shall be operated to prevent or reduce flooding during periods of high water. Those facilities constructed as a part of the protective works shall not be used for purposes other than flood protection without approval of the District Engineer unless designed therefor. (49 Stat. 1571, 50 Stat. 877; and 55 Stat. 638; 33 U.S.C. 701c; 701c-1) (Reg. 9 August 1944, CE SPEWP)

(SEAL)

J. A. ULIO,
Major General,
The Adjutant General.

(P. R. Doc 44-12288; Filed, August 10, 1944;
P. O. A. 70.)

APPENDIX B

ASSURANCES OF LOCAL COOPERATION

AGREEMENT BETWEEN
THE UNITED STATES OF AMERICA
AND
THE STATE OF NEW HAMPSHIRE
FOR LOCAL COOPERATION AT
THE BEAVER BROOK FLOOD DAMAGE REDUCTION PROJECT
KEENE, NEW HAMPSHIRE

THIS AGREEMENT entered into this 27th day of August 1985 by and between the UNITED STATES OF AMERICA (hereinafter called the "Government"), represented by the Contracting Officer executing this Agreement, and the STATE OF NEW HAMPSHIRE (hereinafter called the "State"), acting by and through the Water Resources Board, with the approval of the Governor and Council, WITNESSETH THAT:

WHEREAS, construction of the Beaver Brook Flood Damage Reduction Project in Keene, New Hampshire (hereinafter called the "Project") was approved by the Chief of Engineers on 21 June 1985, under authority granted by Section 205 of the 1948 Flood Control Act, as amended, and Section 61 of the Water Resources Development Act of 1974, Public Law 93-251, 33 U.S.C.A.701s approved 7 March 1974; and

WHEREAS, the State hereby represents that it has the authority and capability to furnish the non-Federal cooperation required by the Federal legislation authorizing the Project and by other applicable law.

NOW, THEREFORE, the parties agree as follows:

1. The State agrees that, if the Government shall commence construction of the Weaver Brook Flood Damage Reduction Project in Keene, New Hampshire, substantially in accordance with the approval of the Chief of Engineers under Section 205 of the 1948 Flood Control Act, as amended and Section 61 of the Water Resources Development Act of 1974, Public Law 93-251, the State shall in consideration of the Government commencing consideration of such Project, fulfill the requirements of non-Federal cooperation specified in such legislation, to wit:

a. Provide all land, easements, rights-of-way, utility and highway relocations and alterations necessary for project construction. Real estate cost are currently estimated to be \$159,000.00. Utility relocations are currently estimated at \$50,000.00.

b. Hold and save the United States free from damages due to the construction, operation and maintenance of the project except where such damages are due to the fault of the United States or its contractors.

c. Maintain and operate the project after completion without cost to the United States in accordance with regulations prescribed by the Secretary of the Army. This subparagraph shall be construed to apply to all aspects of the project including lands acquired within the flood plain which must be maintained in a manner that prevents future encroachment which might interfere with proper flood plain management and the functioning of the project for flood control.

d. Assume full responsibility for all project costs in excess of the Federal statutory limitation of \$4,000,000 which includes costs of all investigations, planning, engineering, supervision, inspection and administration involved in development and project implementation. Total Government participation including investigations and planning costs is estimated to equal \$1,682,000. All costs shall be computed on the basis of actual costs at the completion of the project and not on the basis of estimates contained in the report.

e. Comply with the requirements of non-Federal cooperation specified in Sections 210 and 305 of Public Law 91-646, approved 2 January 1971 entitled the "Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970".

f. Comply with Section 601 Title VI of the Civil Rights Act of 1964 (Public Law 88-352) to the end that no person shall be excluded from participation in, denied the benefits of or subjected to discrimination in connection with the project on the grounds of race, creed, or national origin.


g. Twice yearly inform residents and property owners within the Beaver Brook Flood-plain of the limitations of the flood control improvements and alert them to the continued threat of major flooding along the Brook.

2. The State hereby gives the Government a right to enter, at reasonable times and in a reasonable manner, upon land which it owns or controls, for access to the project for the purpose of inspection. If inspection shows that the State for any reason is failing to operate, repair, manage or maintain the project in accordance with the assurances hereunder and has persisted in such failure after a reasonable notice in writing by the Government delivered to the State of New Hampshire, the Government may enter upon said lands to operate, repair, manage or maintain the project and bill the State for costs incurred. No operation, repair, management or maintenance by the Government in such event shall relieve the State of responsibility to meet its obligation as set forth in paragraph 1 of this agreement, or to preclude the Government from pursuing any other remedy at law or equity.


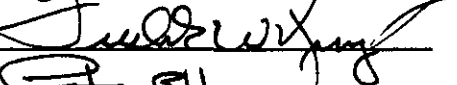
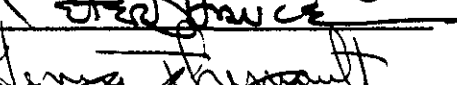
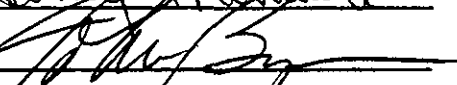

IN WITNESS WHEREOF, the parties hereto have executed
this contract as of the day and year first above written.

THE UNITED STATES OF AMERICA

THE STATE OF NEW HAMPSHIRE

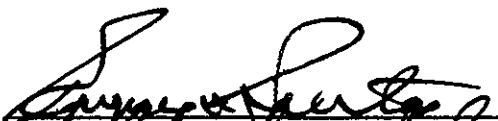
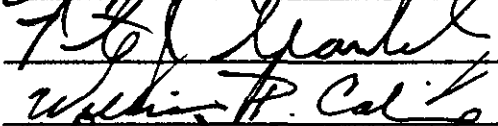

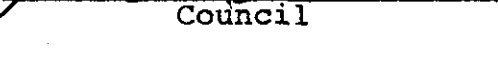
By: 
CARL B. SCIPLE
Colonel, Corps of Engineers
Division Engineer
Contracting Officer

Date: 27 Aug '85

By: 





APPROVED:


Governor





Council

CERTIFICATE OF AUTHORITY

I *R. C. Eason*, do hereby certify that I
(as Attorney General)
am the Attorney General of the State and that the Water
Resources Board is a legally constituted public body with
full authority and legal capacity to perform the terms of
the agreement between the United States of America and the
State of New Hampshire in connection with the Local
Cooperation Agreement for the Beaver Brook Flood Damage
Reduction Project in Keene, New Hampshire, and to pay
damages, if necessary, in the event of the failure to perform
in accordance with Section 221 of Public Law 91-611 and that
the persons who have executed the contract on behalf of the
State of New Hampshire have acted within their statutory
authority.

IN WITNESS WHEREOF, I have made and executed this
certificate this 22d day of August 1985. *PGB*

Assistant *R. C. Eason*
Attorney General of the
State of New Hampshire


CERTIFICATION

STATE OF NEW HAMPSHIRE

SECRETARY OF STATE

I hereby certify that at the date of the attestation hereunto annexed Delbert F. Downing, Fred W. King, Peter B. Hance, Henry Therriault, and John Byrne, who signed this Agreement on behalf of the State of New Hampshire, were then and there the duly appointed directors of the Water Resources Board, that said Agreement was duly signed for an on behalf of the State of New Hampshire as directors of the Water Resources Board, and is within the scope of their statutory powers.

IN WITNESS WHEREOF, I have hereunto affixed my hand and seal of the State of New Hampshire.



Secretary of State

(SEAL)

APPENDIX C

INSPECTION REPORT FORMS

LOCAL FLOOD PROTECTION PROJECT INSPECTION REPORT

Project:

Maintaining Agency:

Type Inspection: _____ **Semi-Annual Staff** _____ **90 Day Interim**

River Basin:

Date of Inspection

Feature	Sat	Unsat	Deficiencies
PUMPING STATIONS - STRUCTURES			
INTERIOR			
EXTERIOR			
PUMPS - MOTORS - ENGINES			
TRIAL OPERATED			
GENERAL CONDITION			
POWER SOURCE			
INSULATION TESTS			
METAL INTAKES/OUTLETS			
GATE VALVES			
GATES - DRAINAGE STRUCTURES			
TRIAL OPERATED			
GENERAL CONDITION			
LUBRICATION			
GENERAL CONDITION			
SLOPES/EROSION			
SAND BOILS/CAVING			
TRESPASSING			
SLOPE PROTECTION			
DRAINS			
STOP-LOGS - LOG BOOM			
CONDITION OF LOGS			
AVAILABILITY OF LOGS			
HIGHWAY SLOTS			
STORAGE FACILITIES			
CHANNELS - OUTLET WORKS CHANNEL			
BANKS			
OBSTRUCTION CONTROL			

Feature	Sat	Unsat	Deficiencies
CONCRETE STRUCTURES			
SURFACE			
SETTLEMENT			
JOINTS			
DRAINS			
MISCELLANEOUS			
EMERGENCY OPER. PLAN			
EMERGENCY EQUIPMENT			
SEMI-ANNUAL REPORT			
Inspection Party: Photographs Taken: Remarks & Additional Comments: (Indicate Here Observations, Discussions, Specific Feature Deficiencies, Recommendations and any other pertinent information. Use Continuation Sheet if necessary.)			
X ALL APPLICABLE ITEMS. IF UNSAT INDICATE SPECIFIC DEFICIENCIES. INDICATE IF NOT APPLICABLE.			
DATE	INSPECTED BY: TYPED NAME & TITLE		SIGNATURE

DESIGNATION OF SUPERINTENDENT

Name Of Project: _____

Location: _____

MAINTAINING MUNICIPAL AGENCY:

Agency: _____

Address: _____ Tel. No. _____

"SUPERINTENDENT" - as required by Section 208.10 (a) (2), Chap II,
Title 33 USC

Name & Title: _____

Employed by: _____

Business Address: _____

Business Tel. No: _____

Nights, Sundays, Address: _____

Nights, Sundays, Tel. No: _____

Remarks:

Signed _____

Title: _____

Date: _____

NOTE: To be submitted and updated as necessary by the responsible agency which will maintain and operate the works in accordance with regulations prescribed by the Secretary of the Army as required by law (Title 33, Chap. 208, Sec II, USC).

APPENDIX D

STANDARD OPERATING PROCEDURES DURING FLOOD PERIODS

APPENDIX D

STANDARD OPERATING PROCEDURES DURING FLOOD PERIODS

I. SCOPE

This appendix describes general details for the operation of flood control features of the Beaver Brook, Keene, New Hampshire, Local Protection Project (LPP) prior to and during flood periods.

II. RESPONSIBILITIES

The City of Keene is responsible for the operation and maintenance of the entire flood protection works. Although the project was designed with a minimum operational requirement the following climatological and hydrological data is provided to assist City officials in determining factors that influence flood conditions along Beaver Brook.

1. Climatology

a) General. A brief description of the climatology and recent flood history of Keene (Ashuelot River Basin) is included as background information for the project superintendent and others concerned with the operation of the facility. It is intended that this information will allow operating personnel to become more aware of the weather and runoff conditions that result in flooding at Keene.

The Beaver Brook watershed has a variable climate characterized by frequent but generally short periods of heavy precipitation. Some intense rainfalls are produced by local thunderstorms and others by larger weather systems of tropical or extratropical origin moving up the eastern coast. The watershed also lies in the path of prevailing westerlies which traverse the country in an easterly or northeasterly direction producing frequent weather changes. Winters are moderately severe, with subzero temperatures rather common. Spring melting of the winter snow cover generally occurs in late March or April.

b) Temperatures. The mean annual temperature at Keene, New Hampshire is approximately 46 degrees Fahrenheit (F), with the average monthly temperatures varying from about 70 degrees F in July to near 20 degrees F in January. Extremes in temperature range from highs slightly in excess of 100 degrees F to lows in the -30 degrees F. Table D-1 summarizes mean, maximum and minimum monthly temperatures recorded at Keene, New Hampshire, for 94 years of record through 1980.

c) Precipitation. The mean annual precipitation at Keene is 38.9 inches, with the greatest annual precipitation of 52.7 inches recorded in 1975 and the least was 27.1 inches recorded in 1894. Table D-2 summarizes the precipitation at Keene for an 89-year period through 1980.

TABLE D-1

**MONTHLY TEMPERATURES
KEENE, NEW HAMPSHIRE
(94 Years of Record Through 1980)
(degrees Fahrenheit)**

Month	Mean	Maximum	Minimum
January	21.3	66	-32
February	22.5	65	-21
March	32.9	85	-21
April	44.6	91	1
May	56.0	95	21
June	64.7	98	27
July	69.5	104	34
August	67.3	102	27
September	60.0	101	19
October	49.3	90	10
November	37.7	80	-15
December	25.5	64	-29
Annual	45.9	104	-32

TABLE D-2

**MONTHLY PRECIPITATION
KEENE, NEW HAMPSHIRE
(89 Years of Record Through 1980)
(inches)**

Month	Mean	Maximum	Minimum
January	2.96	9.24	0.76
February	2.62	7.02	0.57
March	3.20	7.60	0.40
April	3.15	6.65	0.35
May	3.35	7.02	0.79
June	3.46	7.73	0.41
July	3.72	11.09	1.07
August	3.62	8.96	1.05
September	3.53	10.39	0.20
October	2.84	7.84	0.23
November	3.33	7.67	0.52
December	3.16	8.86	0.51
Annual	38.90	52.72	7.10

d) Snowfall. The mean annual snowfall at Keene is about 64 inches. Table D-3 lists mean monthly values, based on 88 years of record through 1980.

TABLE D-3

**MEAN MONTHLY SNOWFALL
KEENE, NEW HAMPSHIRE
(88 Years of Record Through 1980)
(inches)**

Month	Snowfall
January	16.4
February	16.3
March	11.4
April	3.2
October	0.1
November	3.7
December	13.2
Annual	64.3

e) Snow Cover. Snow surveys have been taken in the Ashuelot River watershed since December 1948. These surveys indicate that the water equivalent of the snow cover reaches its average maximum of 4.7 inches about mid-March. Some mean, maximum and minimum water equivalents of snow cover in the Ashuelot basin for the later winter months are listed in Table D-4.

TABLE D-4

**WATER EQUIVALENT OF SNOW COVER
ASHUELOT RIVER WATERSHED
(December 1948-April 1981)
(inches)**

Date	Minimum	Mean	Maximum
01 February	0.1	2.9	7.7
15 February	0.0	3.6	8.5
01 March	0.0	4.3	9.6
15 March	0.0	4.7	9.4
01 April	0.0	3.3	8.9
15 April	0.0	1.2	6.5

2. Hydrological

a) Streamflow. The U.S. Geological Survey has published records of streamflows at 5 locations in the Ashuelot River watershed; however, there are no gaging stations on Beaver Brook. The two nearest gages recording runoff from uncontrolled areas are the South Branch Ashuelot River at Webb, New Hampshire (D.A. 36 square miles) and the Ashuelot River near Gilsum, New Hampshire (D.A. 71.1 square miles). After analyzing the physical characteristics of the drainage areas above these two gages, it was determined that the runoff character of the South Branch Ashuelot was probably most similar to that of Beaver Brook. Mean, maximum and minimum runoff values in cfs and inches for 58 years of record at South Branch are listed in Table D-5. The mean annual runoff is about 58 percent of the mean annual precipitation.

TABLE D-5
MONTHLY RUNOFF
SOUTH BRANCH ASHUELOT RIVER AT WEBB, NEW HAMPSHIRE
(D.A. = 36 square miles)
(58 Years of Record Through 1978)

Month	Average		Maximum		Minimum	
	<u>CFS</u>	<u>Inches</u>	<u>CFS</u>	<u>Inches</u>	<u>CFS</u>	<u>Inches</u>
January	56.6	1.81	161	5.16	6.4	0.20
February	49.8	1.45	153	4.60	9.3	0.27
March	112.0	3.58	366	11.73	23.1	0.74
April	174.0	5.39	356	11.05	64.4	1.99
May	81.1	2.60	186	5.97	26.6	0.85
June	44.1	1.37	151	4.69	7.0	0.22
July	23.0	0.73	102	3.25	3.0	0.09
August	17.0	0.54	131	4.21	2.7	0.09
September	22.1	0.69	252	7.81	2.6	0.08
October	25.9	0.83	133	4.26	2.9	0.09
November	52.4	1.62	244	7.55	3.7	0.11
December	59.9	1.92	178	5.70	9.5	0.30
Annual	59.7	22.50	105	39.9	17.3	6.50

b) History of Floods. Flooding on Beaver Brook has been a recurring problem since the earliest times. Some of the more damaging floods in this century occurred in November 1927, April 1934, March 1936, September 1938, November 1950, October 1959, April 1960 and December 1973. The greatest flood occurred in September 1938.

The September 1938 storm was the result of a stationary cold front along the Atlantic coast overrun by a rapidly moving tropical hurricane, producing record breaking rainfall over large areas of Connecticut, Massachusetts, and New Hampshire. The storm which started with light rain, gradually increased in intensity over the 4-day period (17-21 September). The total rainfall was over 10 inches in the Keene area with a resulting runoff in the area of about 6 inches.

The October 1959 flood was the result of about 4 inches of rain in 24 hours, with 1.5 inches occurring in one hour in the Keene area, and producing high rates of runoff particularly on smaller tributary streams such as Beaver Brook.

The November 1927 event resulted from 4 to 6 inches of rainfall on ground saturated from excessive rains during the previous month. The April 1934 flood was produced by a combination of heavy rains and considerable snowmelt. The March 1936 event resulted from two major rainstorms totaling 6 inches, combined with heavy snowmelt, causing two major rises in river stages about six days apart. The November 1950 flood resulted from 3 to 4 inches of intense rainfall on previously wet ground. The April 1960 event occurred when 3 to 4 inches of rain fell on snow with a high water content. The December 1973 flood was the result of over 3 inches of rainfall on snow covered ground.

c) Flood Frequencies. Peak discharge frequencies for ungaged Beaver Brook were developed utilizing the 58-years of South Branch flow records and computed Beaver Brook flows for selected floods. Flows on Beaver Brook were based on high watermark information and developed stage-discharge relations plus recorded runoff rates from other watersheds in the region. Table D-6 provides information relative to estimated discharge-frequencies for Beaver Brook. Annual peak discharges for the 58-year period of record on the South Branch plus selected Beaver Brook discharges are listed in Table D-7.

TABLE D-6
FREQUENCY OF FLOODING

Frequency (years)	Discharge (cfs)
5	620
10	900
20	1,000
50	1,850
100	2,450

TABLE D-7

ANNUAL PEAK DISCHARGES

Year	South Branch Ashuelot at Webb, NH (D.A. = 36.0 sq. mi.) (cfs)	Beaver Brook at Keene, NH (D.A. = 9.0 sq. mi.) (cfs)	Year	South Branch Ashuelot at Webb, NH	Beaver Brook at Keene, NH
1921	1560		1951	2010	
1922	1160		1952	822	
1923	1400		1953	875	
1924	1220		1954	806	
1925	1680		1955	511	
1926	630		1956	1700	
1927	575		1957	475	
1928	3560		1958	766	
1929	1010		1959	2070	1100 (Oct. 59)
1930	535		1960	4350	600 (Apr. 60)
1931	660		1961	445	
1932	1150		1962	878	
1933	879		1963	758	
1934	879		1964	552	
1935	619		1965	325	
1936	3880	900 (March 1936)	1966	828	
1937	628		1967	750	
1938	5960	2000 (Sept. 1938)	1968	1260	
1939	580		1969	1030	
1940	1910		1970	983	
1941	370		1971	545	
1942	1780		1972	681	
1943	476		1973	1210	900 (Dec. 73)
1944	1470		1974	2520	
1945	725		1975	1870	
1946	1020		1976	1110	
1947	485		1977	2010	
1948	1070		1978	1900	
1949	660				

Mean Log = 3.0077

Standard Deviation = 0.2732

III. DESCRIPTION OF MAJOR PLAN ELEMENTS

a) General. Hydrologic analyses were made of two structural plans of improvement for flood damage reduction on Beaver Brook. One plan increased channel capacity by improving the brook channel and the second reduced floodflows by increasing upstream flood storage. Neither plan provided standard project flood protection but were geared more to providing some flood reduction at least for the more frequent flood events.

b) Channel Improvements. Channel improvements were provided for the damage reach extending from Marlboro to Water Streets, a total distance of approximately 1,750 feet. A 7-foot deep channel with a width varying from 17 to 26 feet was constructed. The improvements were comparable hydraulically, to an improved channel section already built at one location in the reach by the Kingsbury Tool Company. Past improvements to Beaver Brook were generally designed for a flow of about 600 cfs. The improvement would provide some stage reduction for floods in the 10 to 20 year frequency range but would provide negligible reduction for the larger but rarer floods. As stated previously, the lower reach of Beaver Brook is affected by backwater from the Ashuelot "Keene flood plain"; also the gradient of the brook in this reach is extremely flat.

These two features limited the extent of flood reduction possibilities via channel improvements. Any type of channel improvement should be continually maintained free of debris and sediment build-up in order to remain effective.

Three Mile Swamp Storage

a) General. Three Mile Swamp is a natural retention wetland located about 4.5 miles upstream on Beaver Brook. An analysis was made of the outlet structure of this swamp with respect to increasing the flood storage effectiveness of this swamp. Such improvements should not be viewed as a flood control dam and reservoir but simply structural modifications to increase the effectiveness of the natural flood retention area.

b) Dam Modifications. The existing swamp outlet structure was an old stone masonry dam with a 220-foot long stone weir at approximately elevation 790 feet NGVD. This weir resulted in large incremental increases in outflow with relatively small increases in surcharge storage, thereby minimizing the flood modifying potential of the Three Mile Swamp.

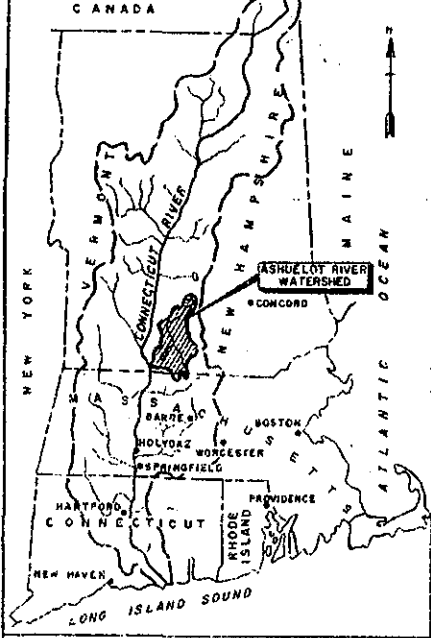
The weir consists of a stepped weir, thus varying delta storage versus delta flow, i.e., "time of storage", with changing magnitude of flow. The outlet is a self-regulating structure with a 7-foot width at elevation 787, 40 feet at elevation 792, and 130 feet at elevation 794 feet NGVD.

c) Earth Dike. In order to obtain flood surcharge storage at Three Mile Swamp, an earth dike was constructed adjacent to New Hampshire Route 10 which is below the top of dike elevation for several hundred feet upstream of the outlet structure. The dike extends 1,100 feet upstream of the outlet structure and has a top width of 12 feet at elevation 799 feet NGVD. This elevation provides two feet of freeboard over the Standard Project Flood pool elevation of 797 feet NGVD. The height of dike above the Route 10 road surface varies from 7 feet at the outlet structure to two feet at its upstream limit. The dike was constructed of compacted gravel and impervious fill with a layer of stone protection on a gravel bedding on the wetland side and seeded and topsoiled adjacent to Route 10.

IV. OPERATIONAL CONSIDERATION

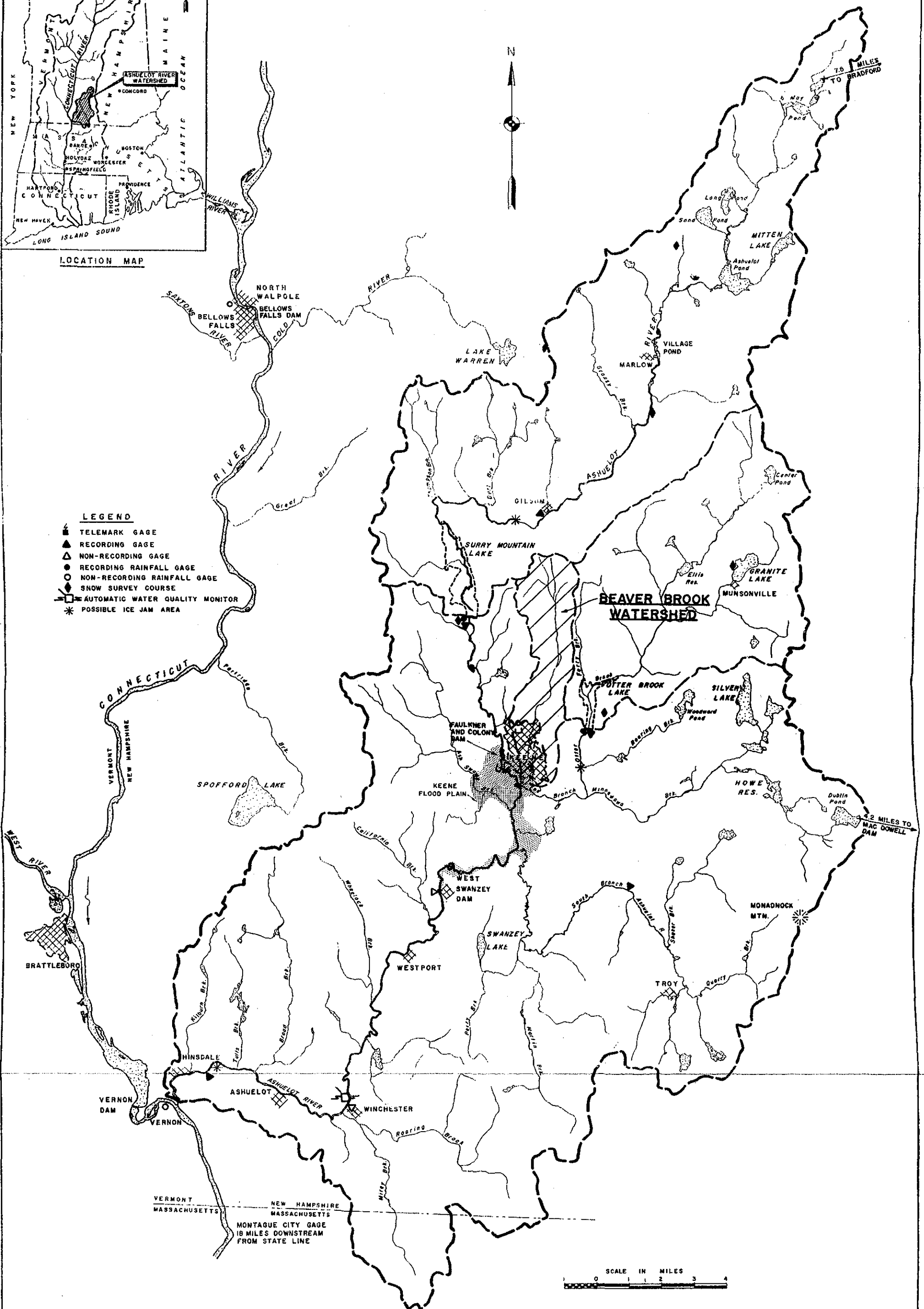
The project features are designed to operate automatically with no action required by Keene officials during flood periods. The outlet structure at Three Mile Swamp is a self-regulating spillway with no gateworks that require operation during flood periods.

One exception to the absence of an operational requirement is the earth dike located adjacent to New Hampshire Route 10 which provides two feet of freeboard against the stage of a Standard Project Flood (SPF). At the point where the dike alignment intersects Route 10 the surface elevation of the roadway is two feet lower than the top of dike, representing an opening in the freeboard range. If freeboard protection was ever required during a rare SPF flood, the City of Keene would have to temporarily close Route 10 and sandbag the roadway to maintain control of flood flows.



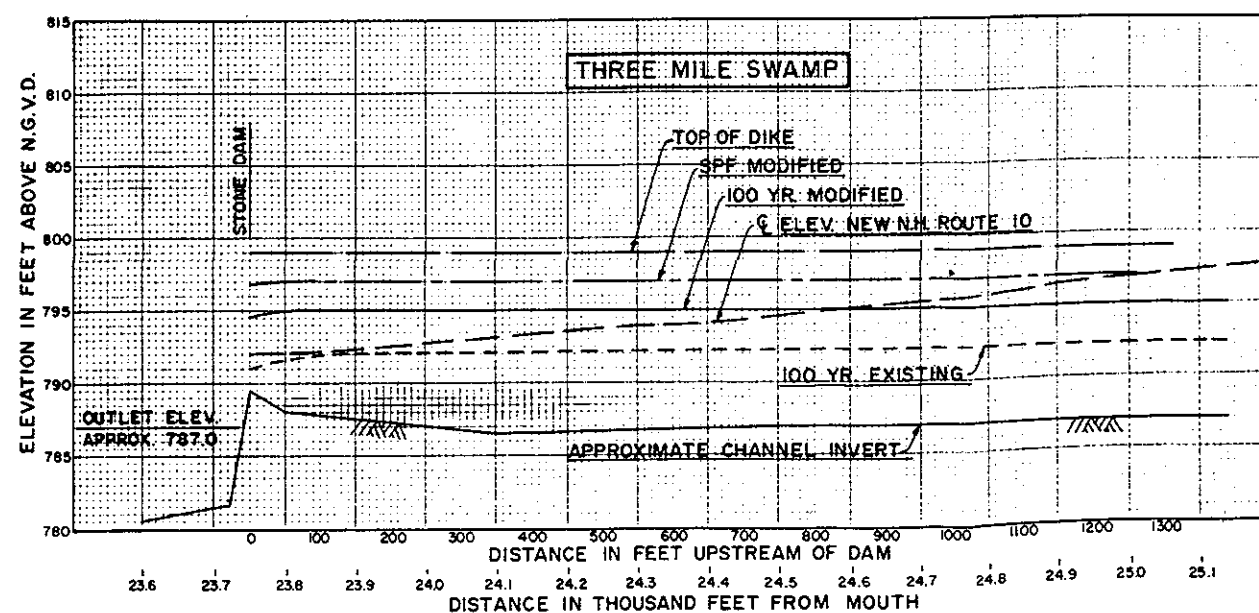
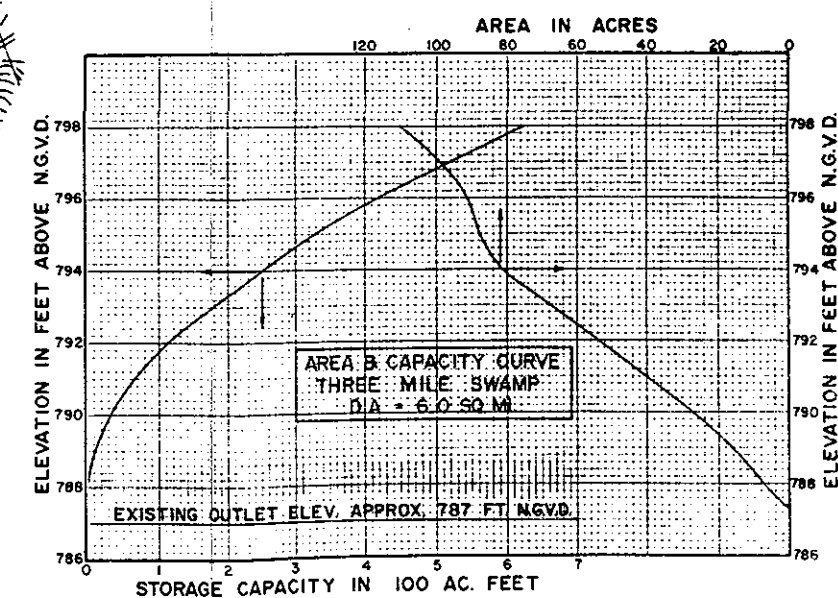
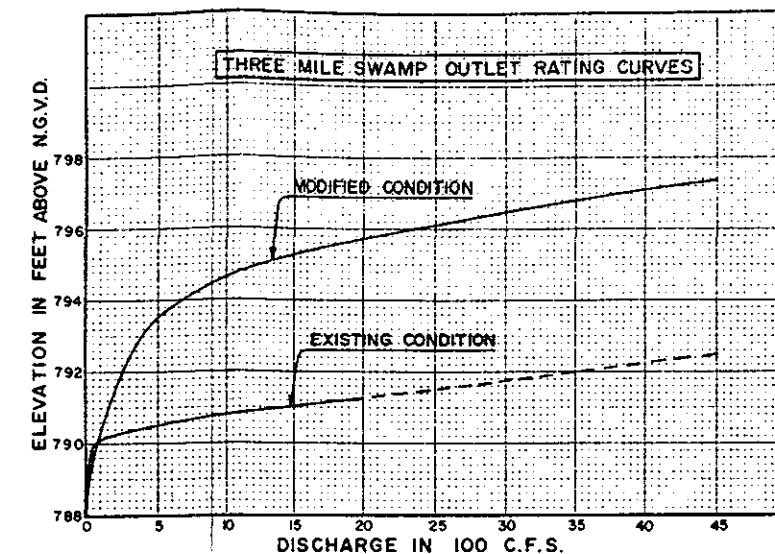
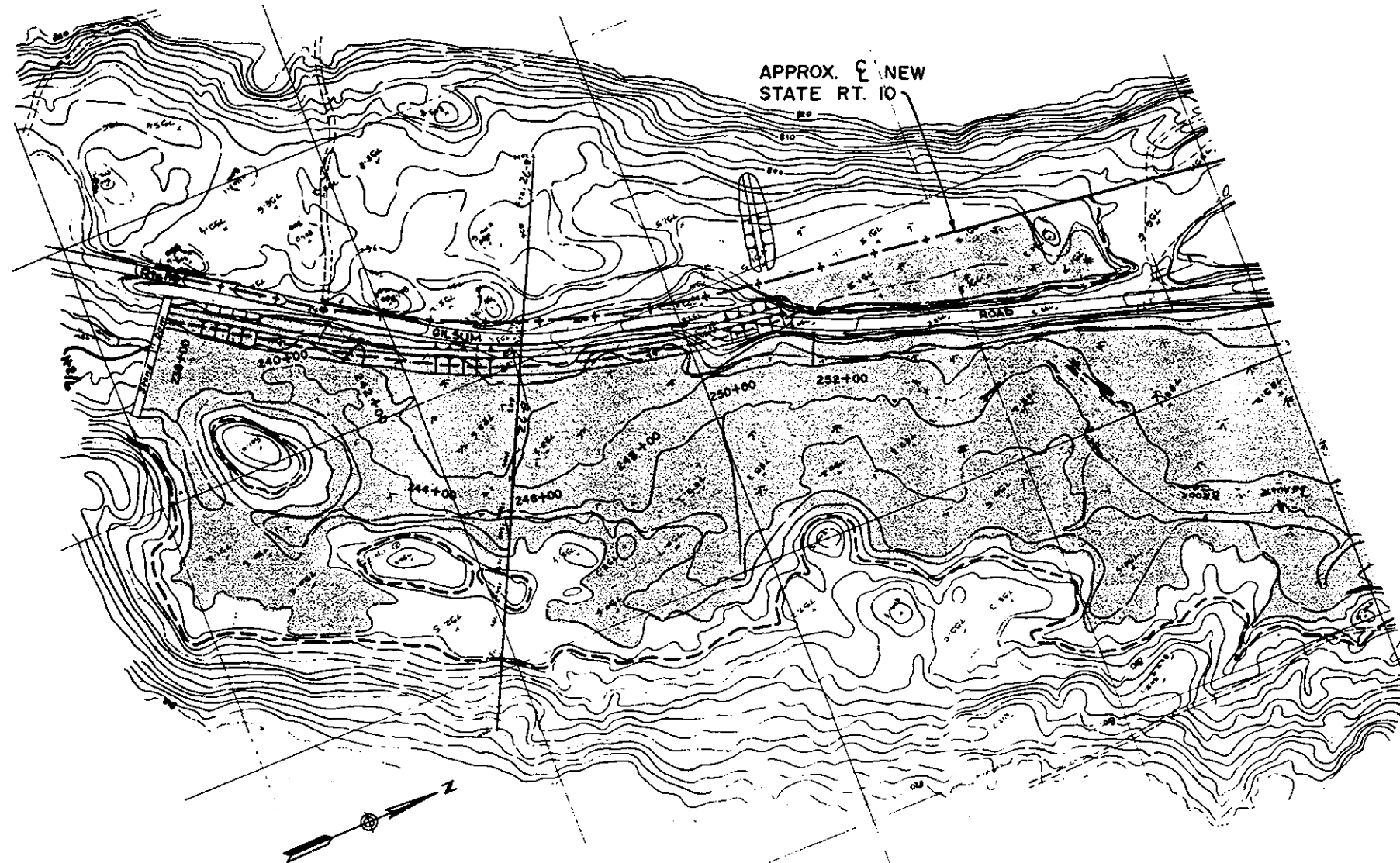
LOCATION MAP

- LEGEND**
- TELEMARK GAGE
 - RECORDING GAGE
 - NON-RECORDING GAGE
 - RECORDING RAINFALL GAGE
 - NON-RECORDING RAINFALL GAGE
 - SNOW SURVEY COURSE
 - AUTOMATIC WATER QUALITY MONITOR
 - POSSIBLE ICE JAM AREA



SCALE IN MILES
0 1 2 3 4

CONNECTICUT RIVER FLOOD CONTROL
ASHUELOT RIVER
WATERSHED MAP
DEPARTMENT OF THE ARMY - NEW ENGLAND DIVISION
CORPS OF ENGINEERS - WALTHAM, MASS.
NOVEMBER 1971



LEGEND

- EXISTING 100 YEAR FLOOD LIMITS
- MODIFIED 100 YEAR FLOOD LIMITS

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

ASHUELOT RIVER BASIN
BEAVER BROOK KEENE, N.H.

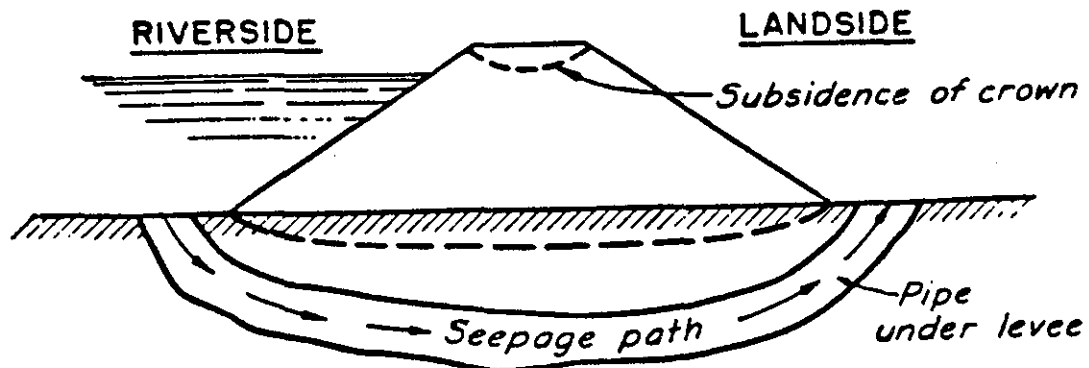
THREE MILE SWAMP

PLAN & PROFILE, OUTLET RATING CURVES
AND AREA CAPACITY CURVES

HYDRO. ENG. SECT. FEB. 1983

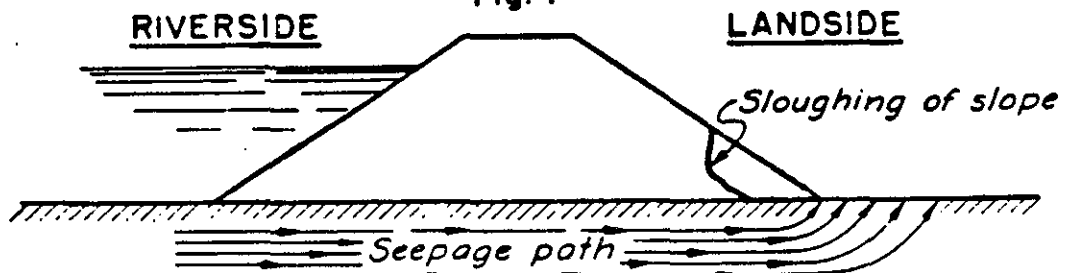
APPENDIX E

FLOOD EMERGENCY MEASURES



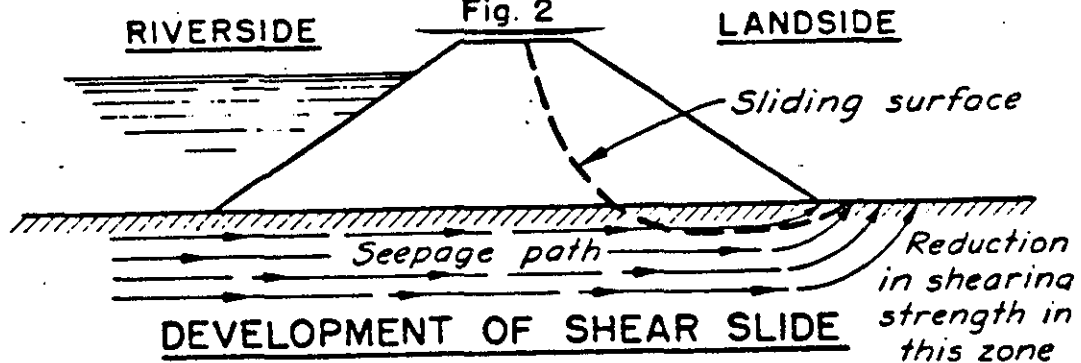
DEVELOPMENT OF PIPE UNDER LEVEE

Fig. 1



SLOUGHING OF LANDSLIDE SLOPE DUE TO RAVELLING AND UNDERCUTTING OF TOE

Fig. 2



DEVELOPMENT OF SHEAR SLIDE

Fig. 3

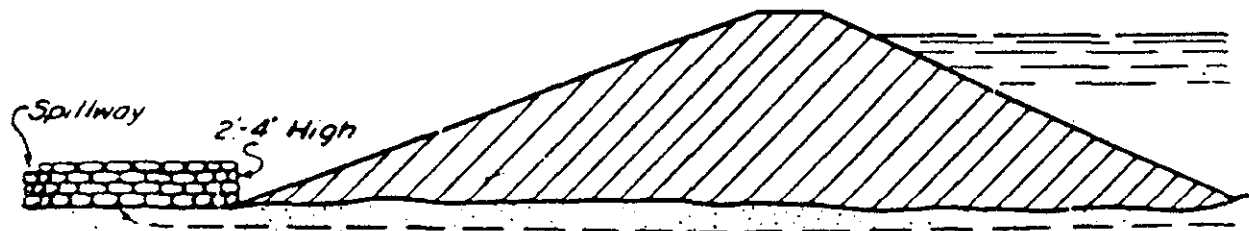
EFFECTS OF
SAND BOILS
ON LEVEE

U.S. Army Corps of Engineers
New England Division
Waltham, MA

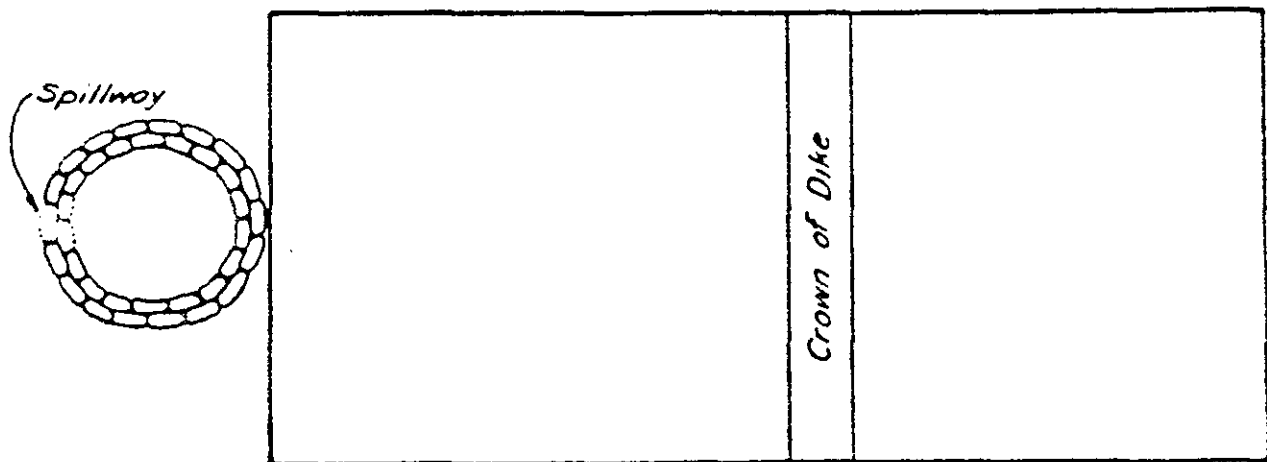
EMERGENCY PROCEDURE MANUAL
FOR DISASTER RELIEF

(VOLUME II, PART I)
"FLOOD FIGHTING"

PLATE 1



Wall should be built on firm ELEVATION
 foundation, with width of base
 at least $1\frac{1}{2}$ times the height.
 Be sure to place sacks on ground
 clear of sand discharge..
 Tie into dike if boil is near toe.

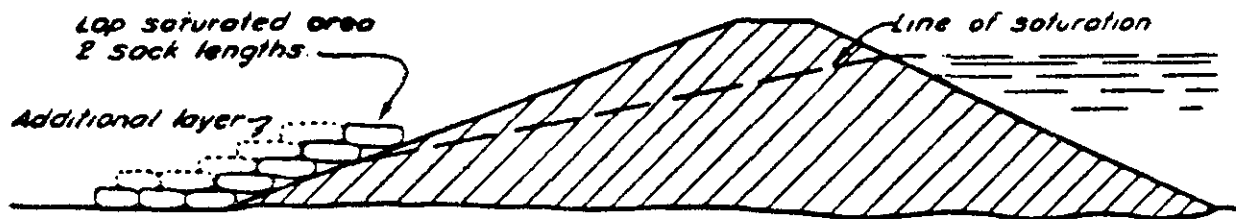


PLAN

*Do not sock bail which
 does not put out material.
 Height of sock loop or ring
 should be only sufficient to
 create enough head to slow
 down flow through bail so
 that no more material is dis-
 placed and boil runs clear.
 Do not try to stop fully, flow
 through bail.*

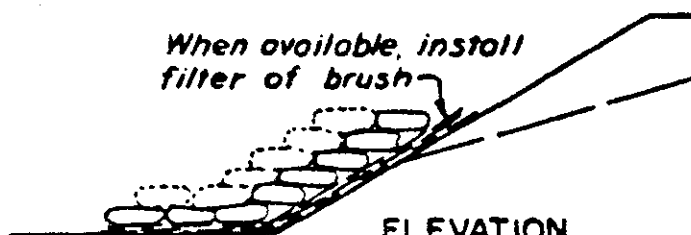
U.S. Army Corps of Engineers
 New England Division
 Waltham, MA

**SAND BOIL
 STANDARD HIGH WATER
 MAINTENANCE INSTRUCTION**

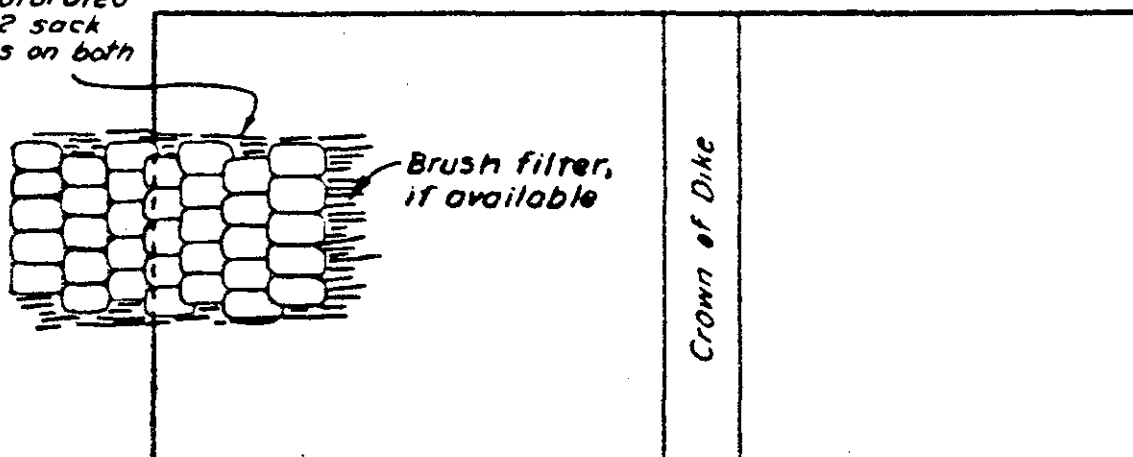


ELEVATION

Number of layers deter-
mined by velocity of
seepage and amount of
material being carried



Lap saturated
area 2 sack
widths on both
ends.



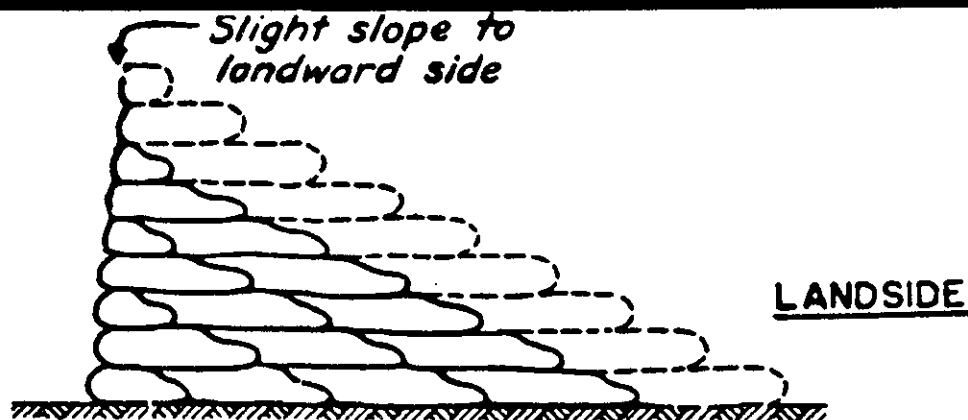
PLAN

Socks should be laid
shingle fashion and not
matted into place

U.S. Army Corps of Engineers
New England Division
Waltham, MA

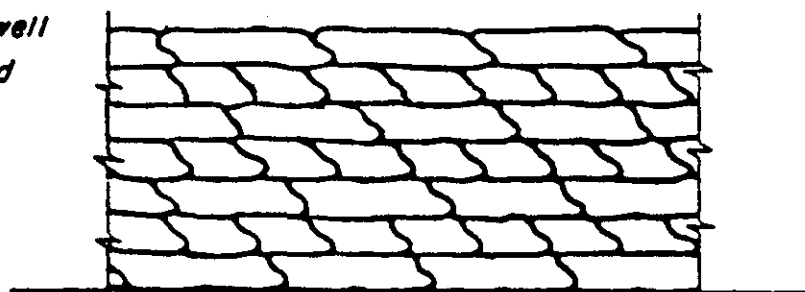
**SACKING SLOUGHS
STANDARD HIGH WATER
MAINTENANCE INSTRUCTION**

RIVERSIDE



SECTION

Note: Sacks should be lapped at least $\frac{1}{3}$ all ways and well mounded or tamped into place.



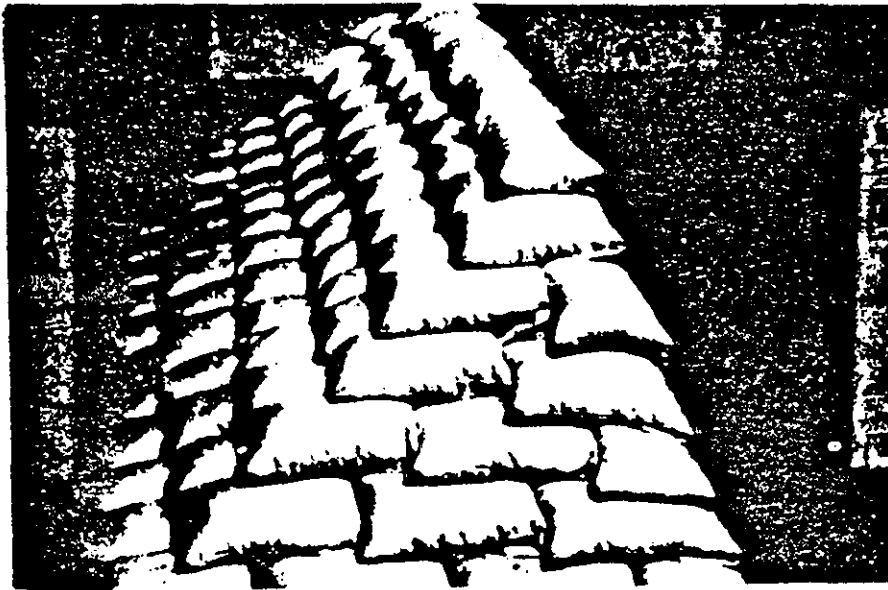
RIVERSIDE ELEVATION

SACKS REQUIRED PER 100' STA.
100 lb. "Feed" Sacks - 1 Cu. Ft. Each

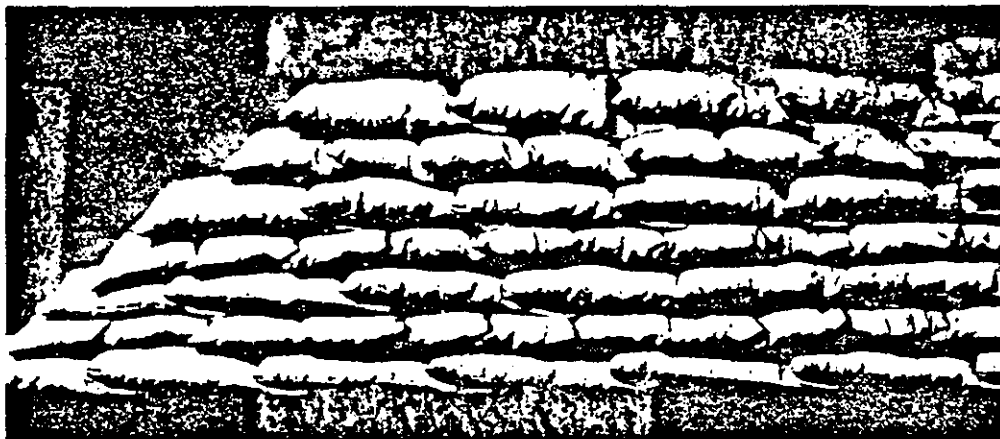
Approx. Hgt. Sack Dike	Sacks High	Required
1.5	3	300
2.0	4	750
3.0	6	1400
4.0	8	2250
5.0	10	3250
6.0	12	4500
7.0	14	5950
8.0	16	7600

U.S. Army Corps of Engineers
New England Division
Waltham, MA

**SACK DIKE OR TOPPING
STANDARD HIGH WATER
MAINTENANCE INSTRUCTION**



**MODEL SACK DIKE OR TOPPING
TYPICAL SECTION**



**MODEL SACK DIKE OR TOPPING
RIVERSIDE VIEW**

**U.S. Army Corps of Engineers
New England Division
Waltham, MA**

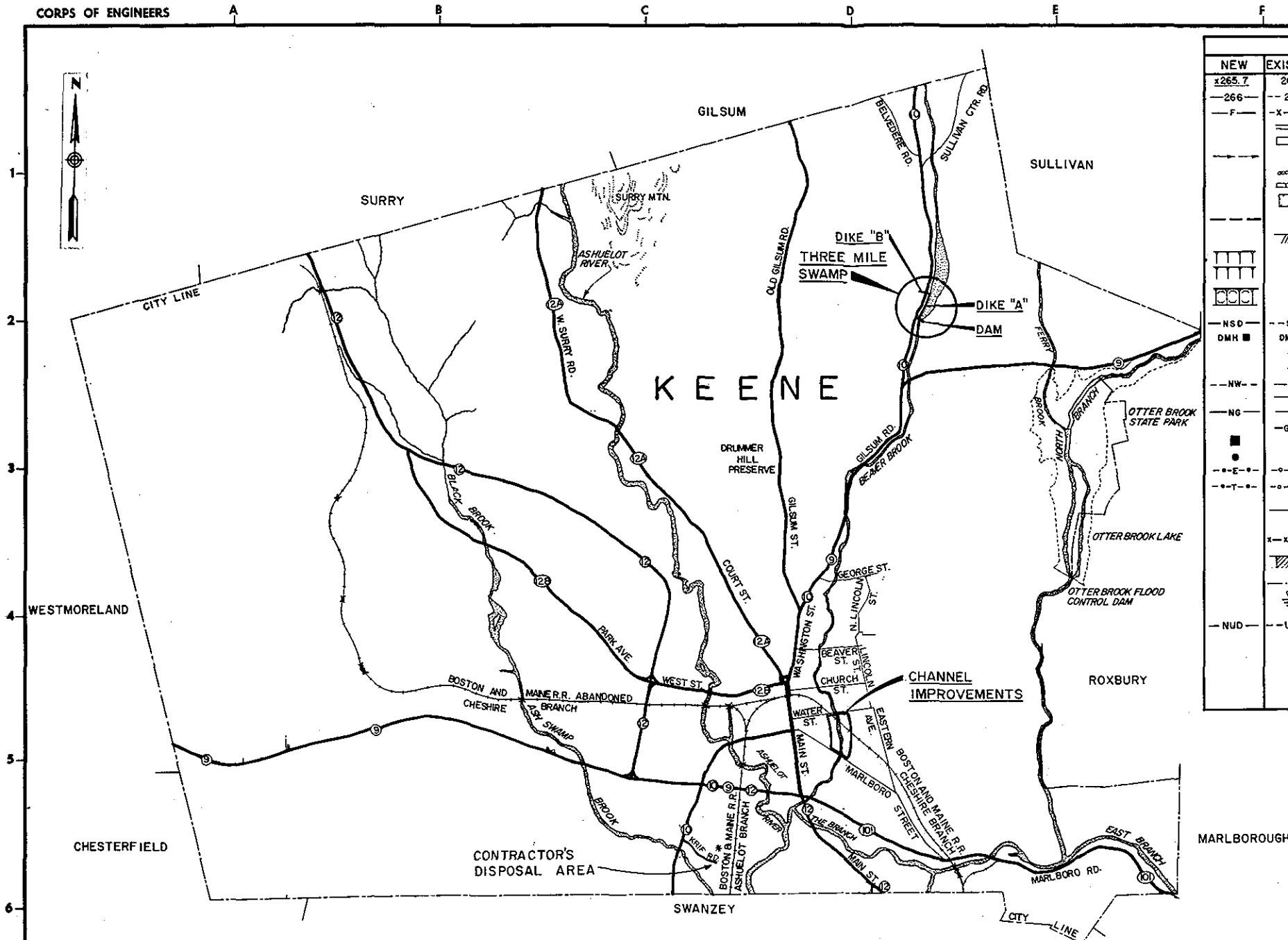
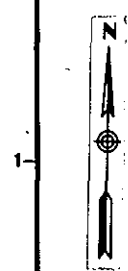
MODEL SACK DIKE OR TOPPING

**TOP VIEW - TYPICAL SECTION
BOTTOM VIEW - RIVERSIDE VIEW**

PLATE 5

APPENDIX F

AS-BUILT DRAWINGS

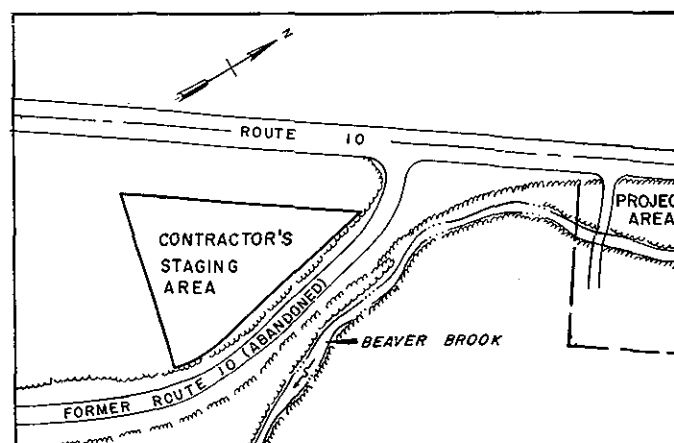


GENERAL PLAN

SCALE: 1" = 0.36 MI. ±

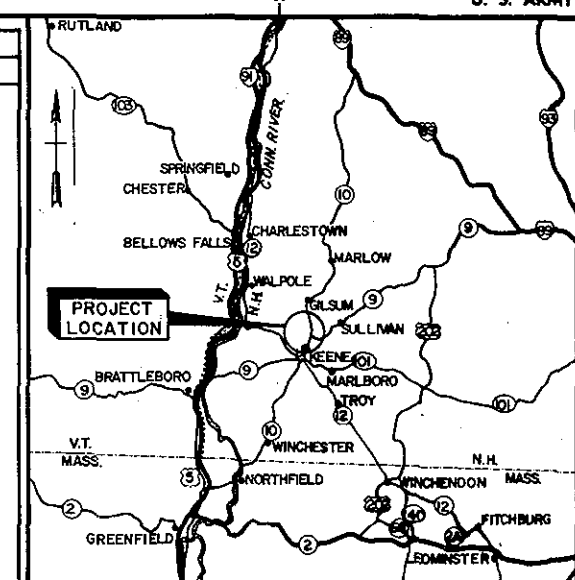
GENERAL NOTES:

1. ALL ELEVATIONS REFER TO THE NATIONAL GEODETIC VERTICAL DATUM (NGVD).
2. COORDINATES REFER TO STATE OF NEW HAMPSHIRE SYSTEM.
3. DATE OF SURVEY: NOV. 1984.

THREE MILE SWAMP
LOCATION OF CONTRACTOR'S STAGING AREA

SCALE: 1" = 100'

LEGEND		
NEW	EXISTING	DESCRIPTION
265.7	263.5	ELEVATIONS
266	266	CONTOURS
F	X-EF-X	FENCE
		ROADS OR WALKS
		PAVED AREAS
		GRADE TO DRAIN
		STONE WALL
		CURBING
		BUILDINGS
		LIMIT OF CONTRACTOR'S WORK AREA
		EXISTING GROUND
		EARTH CUT
		EARTH FILL W/ ROCK SLOPE PROTECTION
NSD	SD	STORM DRAIN
DMH	DMH	DRAIN MANHOLE
		SANITARY MANHOLE
		FIRE HYDRANT
NW	EW	WATER LINE
NG	SS	SANITARY SEWER LINE
	G	GAS LINE
	GASO	GASOLINE LINE
	CB	CATCH BASIN
	P	POLE
E	E	ELECTRICAL LINE OVERHEAD
T	T	TELEPHONE LINE OVERHEAD
		TELEPHONE LINE UNDERGROUND
X-X-X-X		EXISTING UTILITIES TO BE ABANDONED
		BEDROCK
		EDGE OF WATER
		LEVEL OF WATER AT TIME OF SURVEY
NUD	UD	UNDERDRAIN



LOCATION MAP

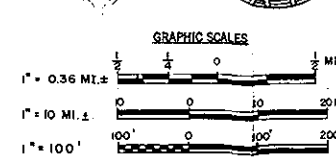
SCALE: 1" = 10 MI. APPROX.

INDEX TO DRAWINGS

DRAWING NO.	SH. NO.	TITLE
KEE-1	1	GENERAL PLAN AND INDEX
"	2	THREE MILE SWAMP GEOLOGIC LOG PROFILE-DAM
"	3	DAM PLAN AND DIKE "A" PLAN NO. 1
"	4	DIKE "A" PLAN NO. 2 & SECTIONS
"	5	"
"	6	"
"	7	AND DIKE "B" PLAN
"	7A	DAM PROFILE & SECTIONS NO. 1
"	8	DAM SECTIONS NO. 2
"	9	"
"	10	"
"	11	DAM PLAN & ELEVATION SPILLWAY & STILLING BASIN SECTIONS
"	12	LEFT & RIGHT DAM ABUTMENTS PLAN & SECTIONS
"	13	STOP LOG STRUCTURE PLAN & SECTIONS
"	14	MISCELLANEOUS DIKE SECTIONS
"	15	DRAINAGE DETAILS
"	16	MISCELLANEOUS DETAILS
"	17	CONTROL
"	17A	CONTROL AND DIVERSION OF WATER
"	18	CHANNEL IMPROVEMENT PLAN & SECTIONS NO. 1
"	19	PLAN & SECTIONS NO. 2
"	20	PLAN & SECTIONS NO. 3
"	21	PLAN & SECTIONS NO. 4
"	22	CONTROL
"	23	WING WALLS
"	24	PRECAST MODULAR RETAINING WALLS

As Built Drawing

Contract No. DACW 33-85C-0053



REVISION	DATE	DESCRIPTION
5/3/90	Final field corrections	
9/3/85	Index, Legend and Title revised (Am. #1)	

DESIGNED BY	CHKD BY	APP'D BY	DATE
M.A.G.	A.D.	M.A.G.	

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

WATER RESOURCES DEVELOPMENT PROJECT
KEENE, NEW HAMPSHIRE

LOCAL PROTECTION PROJECT
GENERAL PLAN AND INDEX

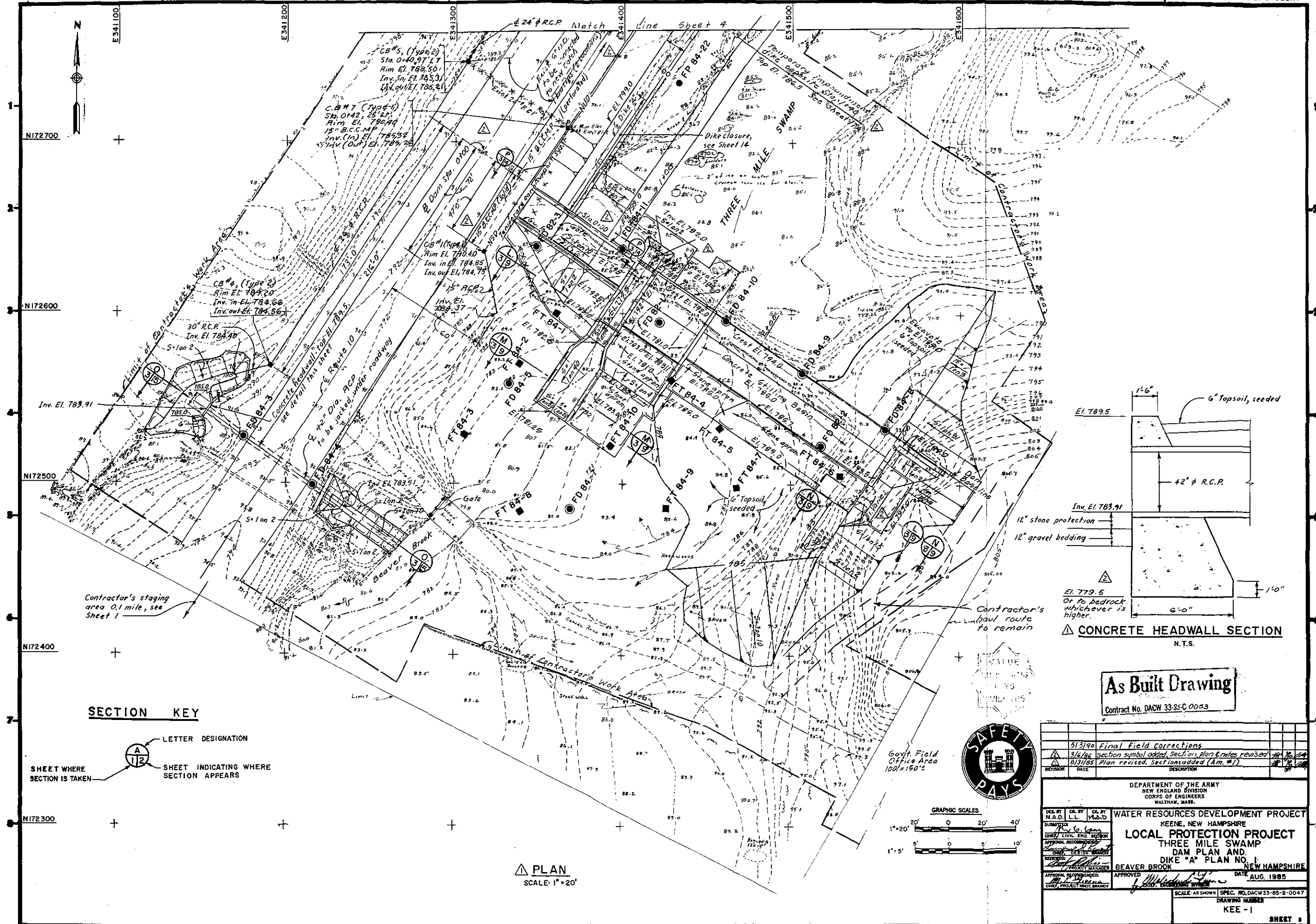
BEAVER BROOK
NEW HAMPSHIRE

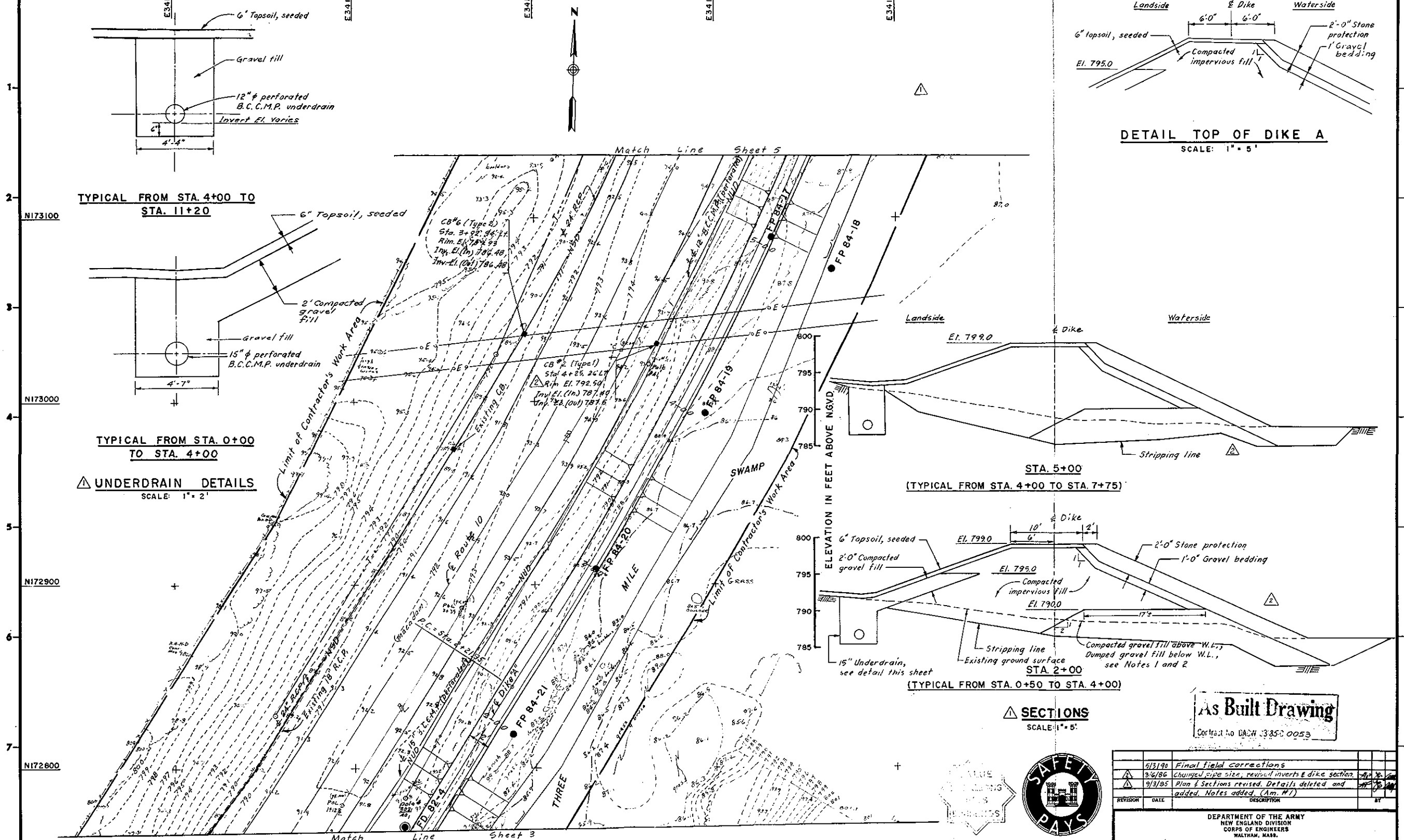
APPROVED: *[Signature]* DATE: AUG. 1985

SCALE: AS SHOWN | SPEC. NO. DACW 33-85-B-0047

DRAWING NUMBER
KEE-1

SHEET 1





TYPICAL FROM STA. 4+00 TO STA. 11+20

TYPICAL FROM STA. 0+00 TO STA. 4+00

UNDERDRAIN DETAILS
SCALE: 1" = 2'

DETAIL TOP OF DIKE A
SCALE: 1" = 5'

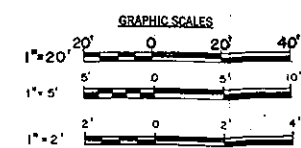
SECTIONS
SCALE: 1" = 5'

As Built Drawing

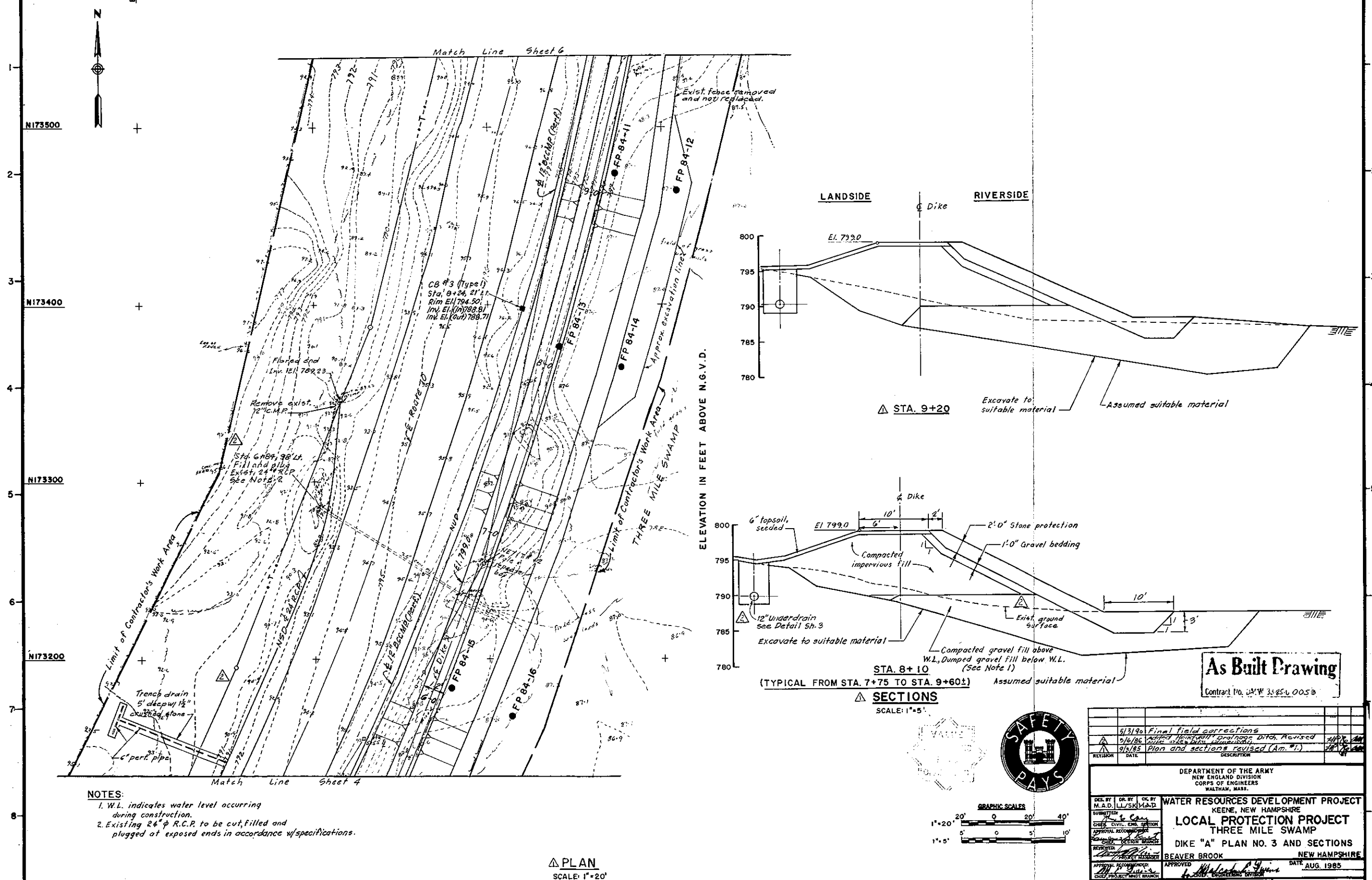
Contract No. DACW 33-85-00053

- NOTES:
1. W.L. indicates water level occurring during construction
 2. The gravel fill zone on the waterside of Dike "A" is deleted from Sta. 0+00 to Sta. 0+50 and replaced with compacted impervious fill.
 3. Existing overhead telephone lines along landside toe of dike to be relocated by others to the West side of Route 10 as shown prior to 31 July 1985.

PLAN
SCALE: 1" = 20'



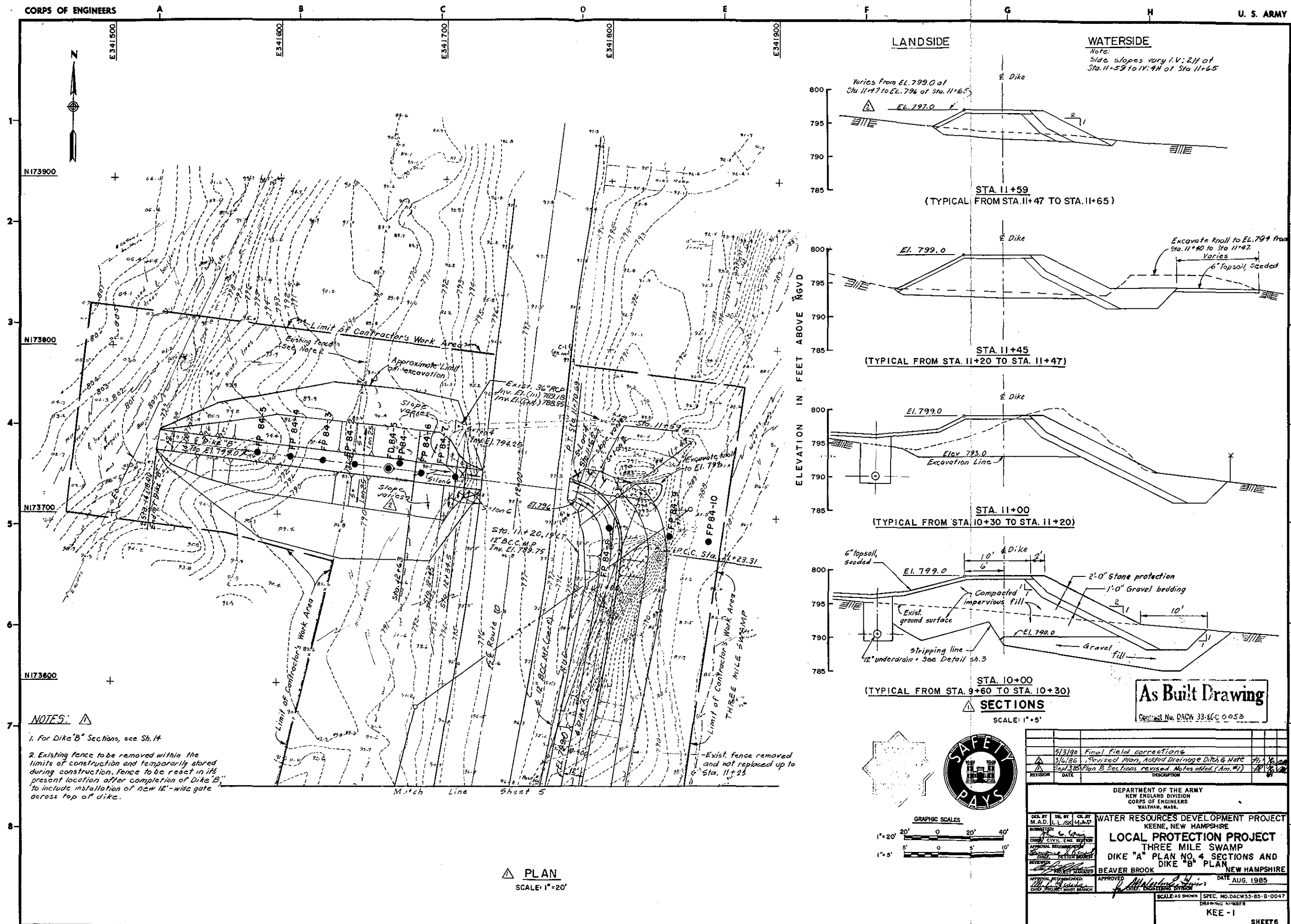
5/31/90	Final field corrections	
3/6/86	changed pipe size, revised inverts & dike section	
9/3/85	Plan & Sections revised. Details deleted and added. Notes added. (Am. #1)	
REVISION	DATE	DESCRIPTION
DEPARTMENT OF THE ARMY NEW ENGLAND DIVISION CORPS OF ENGINEERS WALTHAM, MASS.		
WATER RESOURCES DEVELOPMENT PROJECT KEENE, NEW HAMPSHIRE LOCAL PROTECTION PROJECT THREE MILE SWAMP DIKE "A" PLAN NO. 2 AND SECTIONS BEAVER BROOK NEW HAMPSHIRE DATE AUG. 1985		
SCALE AS SHOWN SPEC. NO. DACW 33-85-00047 DRAWING NUMBER KEE - 1' SHEET 4		

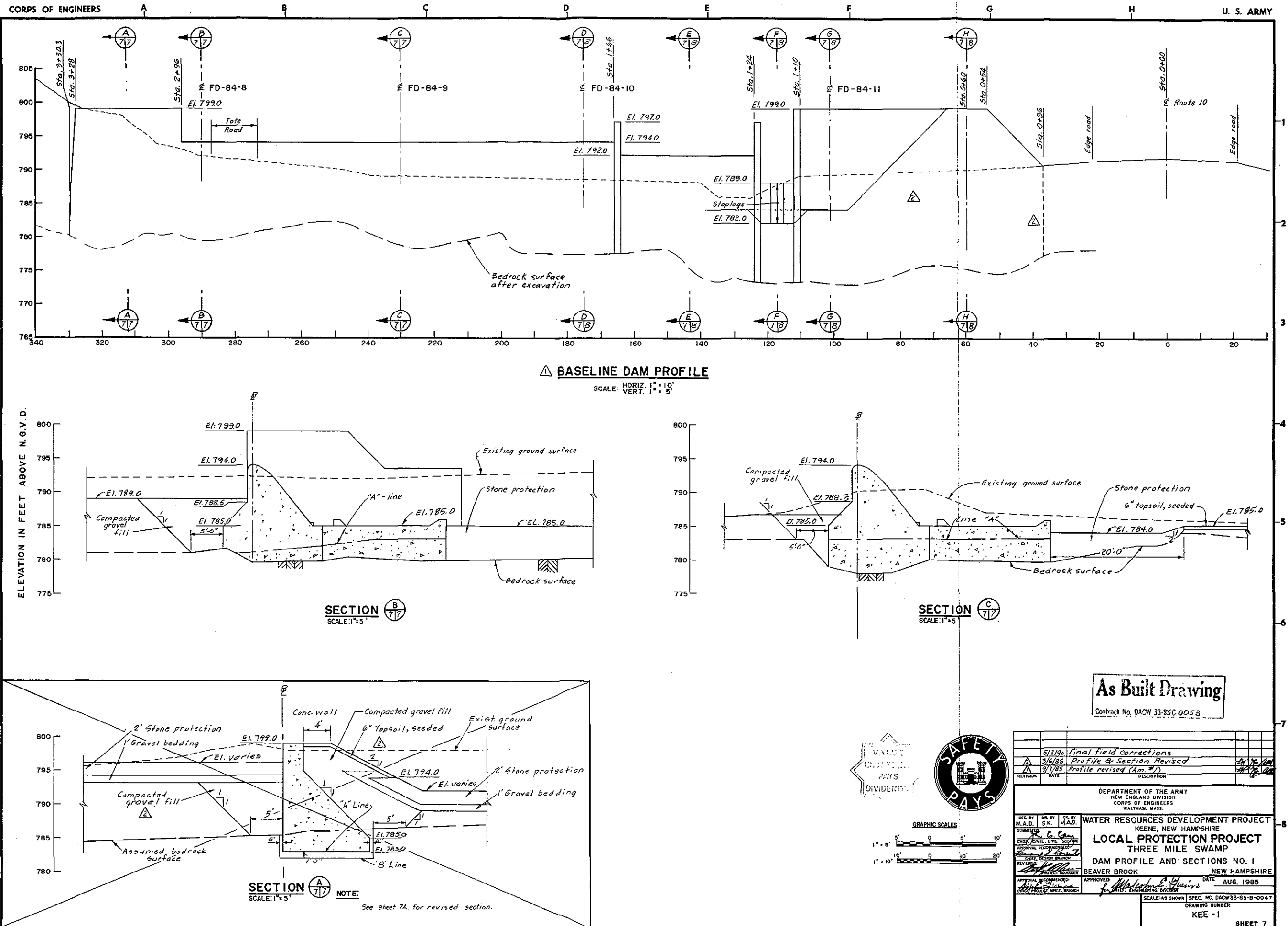


As Built Drawing

Contract No. DA-7W-3-85-L-0053

[illegible]



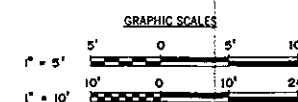


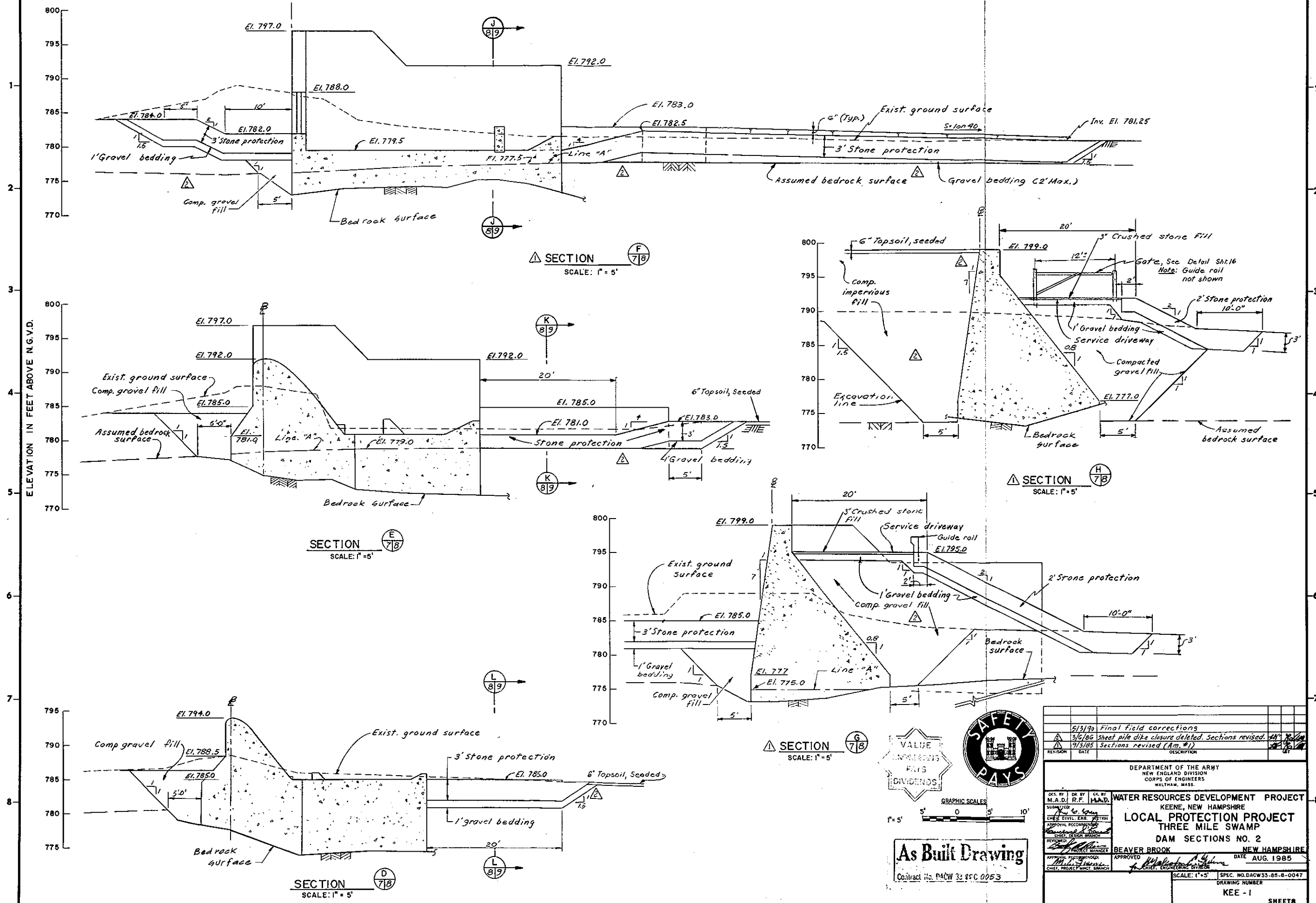


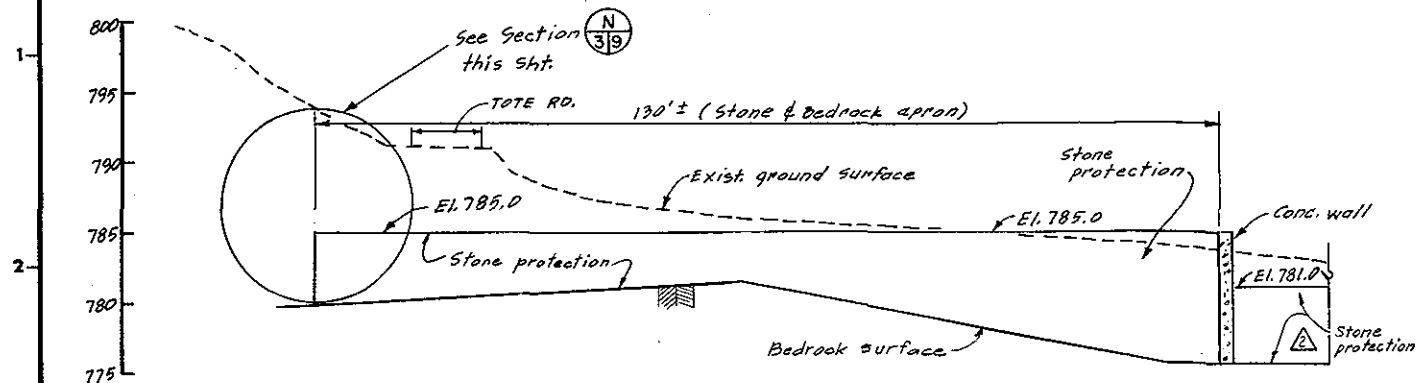
1. Bedrock shown is approximate based on field observations along the new dam 2.
2. Construct all fills to the limits of existing actual excavation lines.
3. Top elevation of new stone protection upstream of new dam on left (East) abutment is changed to elevation 799.0. Slope above this stone protection is changed to 1 vertical on 2 horizontal to match slope for downstream left abutment.
4. The entire excavation around the left abutment is considered to be a restricted area for compaction purposes. Requirements for compaction of impervious fill material in a restricted area as specified in Section 02222 - EARTH FILLS of the contract specifications shall be strictly adhered to.
Special compaction of impervious fill material as specified in Section - EARTH FILLS, paragraph 9.4 is required adjacent to all faces of the new concrete dam, and all provisions shall be strictly adhered to.
5. The upstream face of the two monoliths for the new concrete dam located between Station 2+96 and Station 3+28, and the end face of the dam at Station 3+28, are changed from vertical to a 7 vertical on 1 horizontal batter.
6. The downstream slope of the end monolith located between Station 3+11 and Station 3+28 is changed from 3 vertical on 2 horizontal to 1 vertical on 1 horizontal.

As Built Drawing

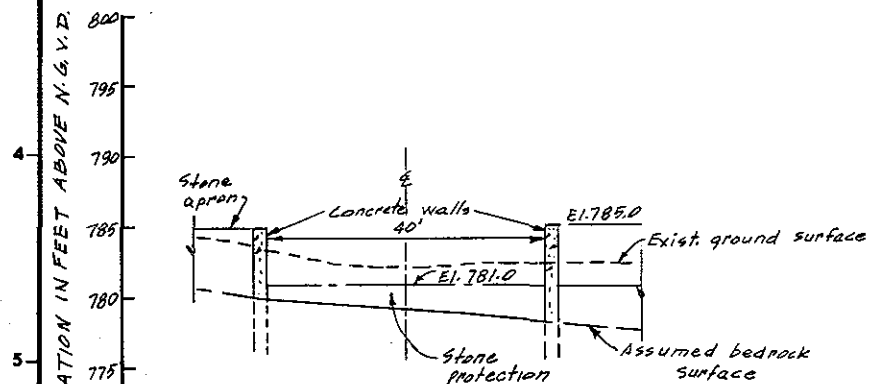
Contract No. DACY 33-85-C-0053

[illegible]

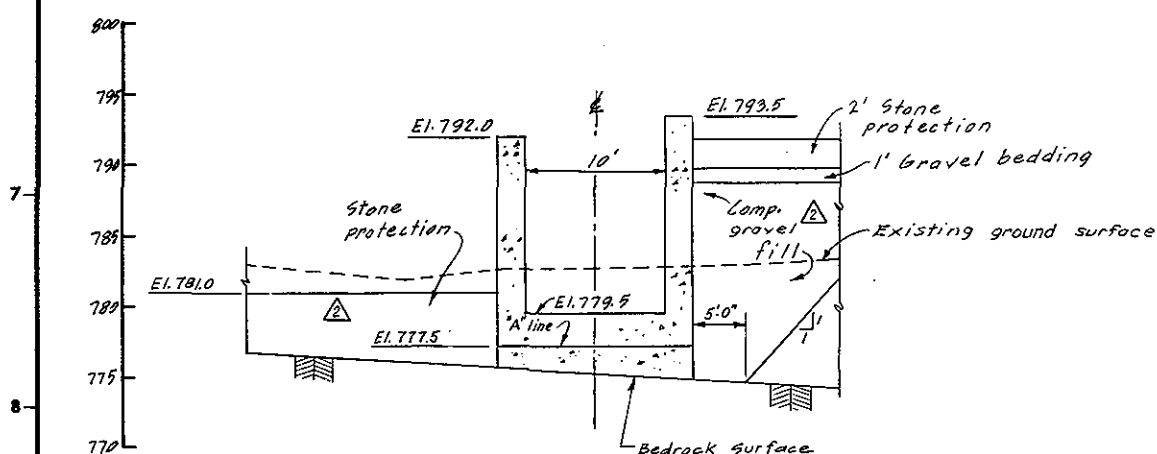




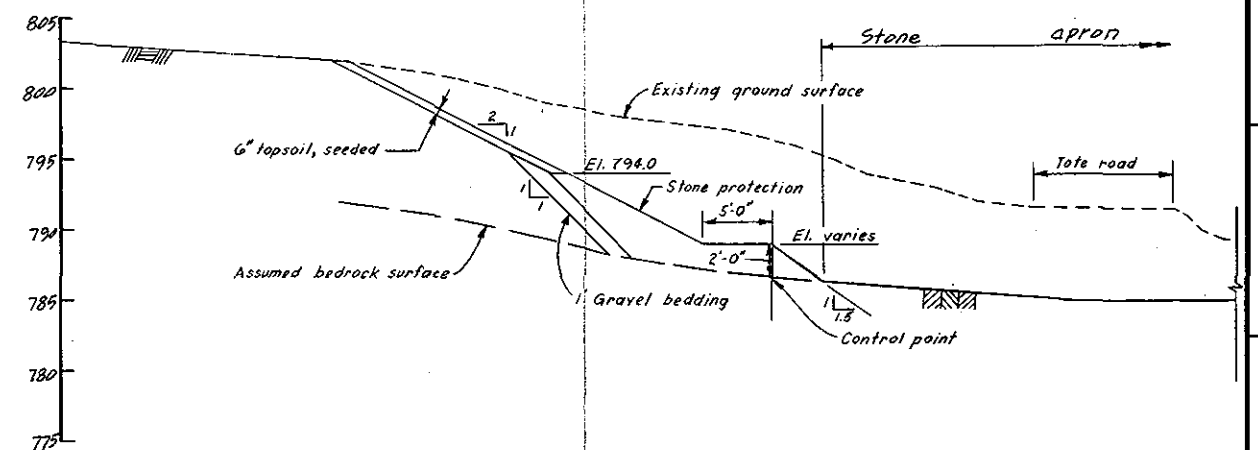
SECTION N 319
SCALE: HORIZ. 1" = 10'
VERT. 1" = 5'



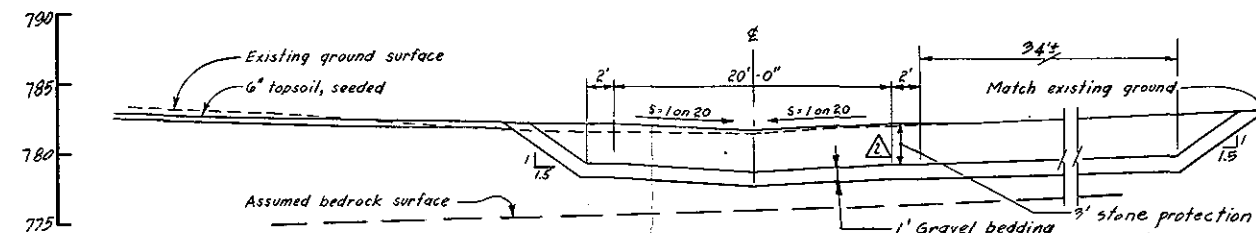
SECTION K 819
SCALE: HORIZ. 1" = 10'
VERT. 1" = 5'



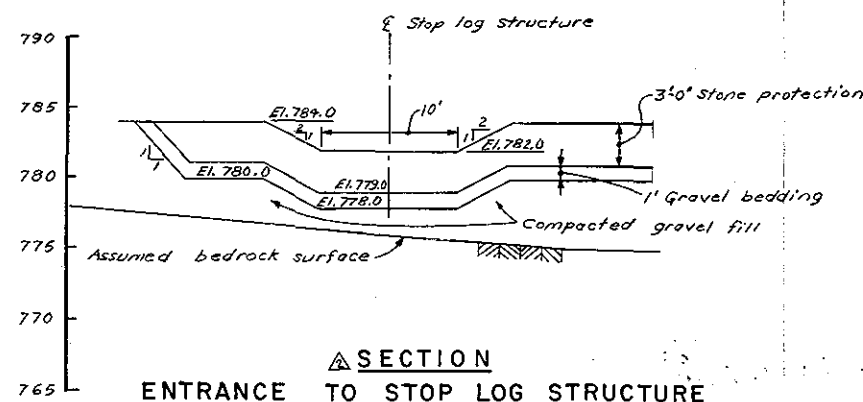
SECTION J 819
SCALE: 1" = 5'



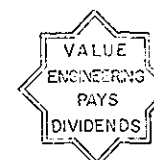
SECTION N 319
SCALE: 1" = 5'



SECTION M 319
SCALE: 1" = 5'

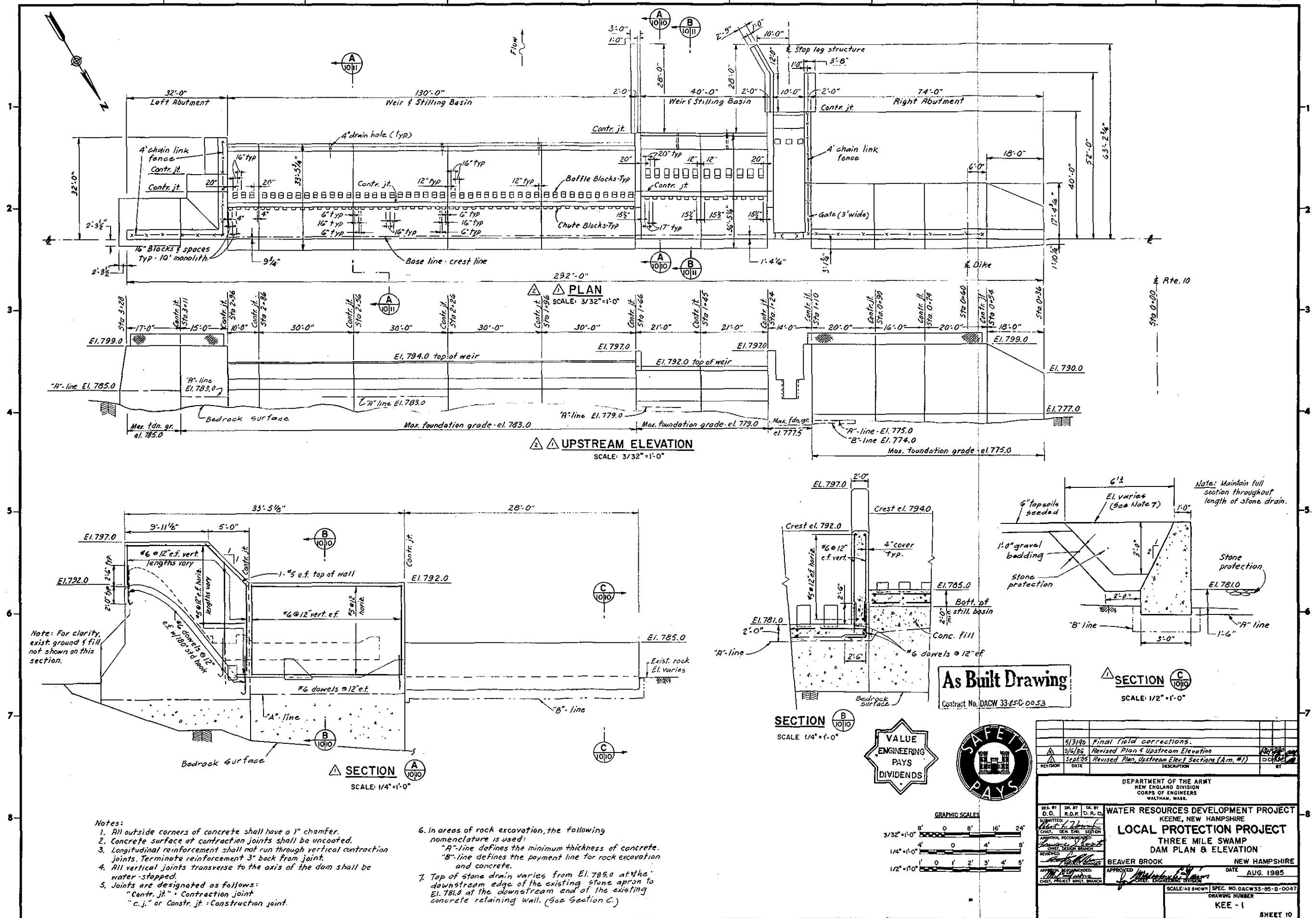


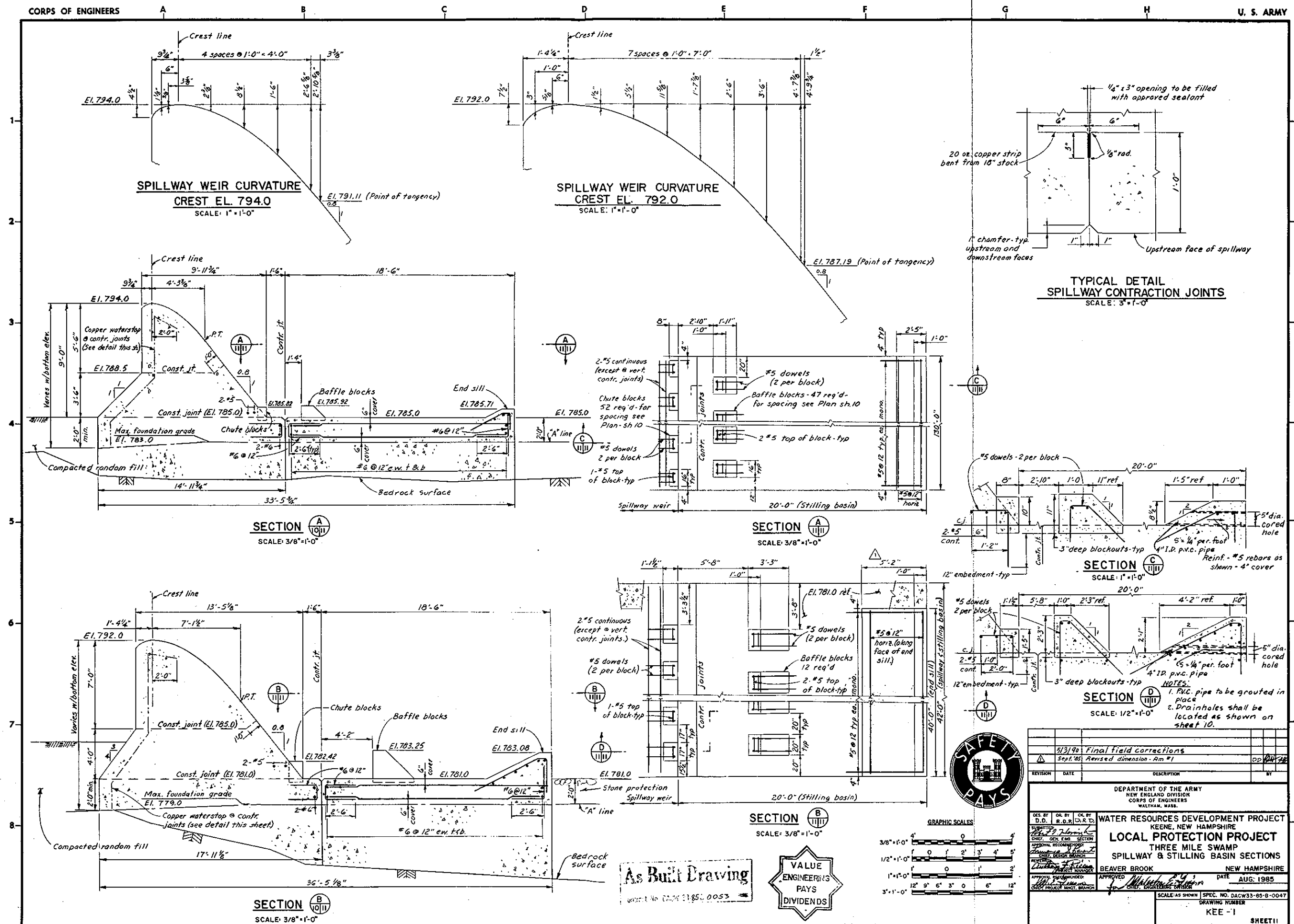
SECTION N 319
ENTRANCE TO STOP LOG STRUCTURE
SCALE: 1" = 5'

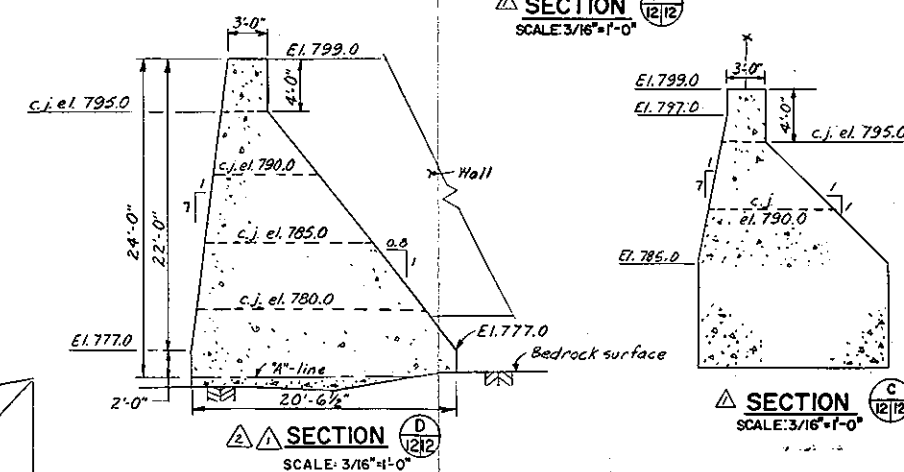
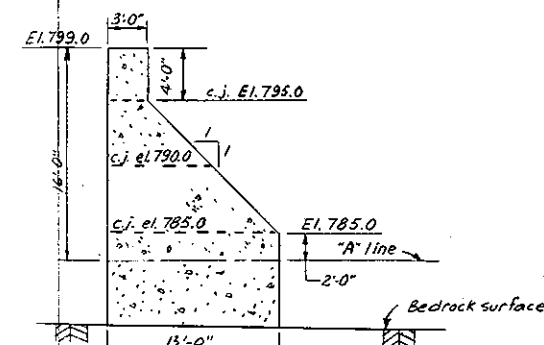
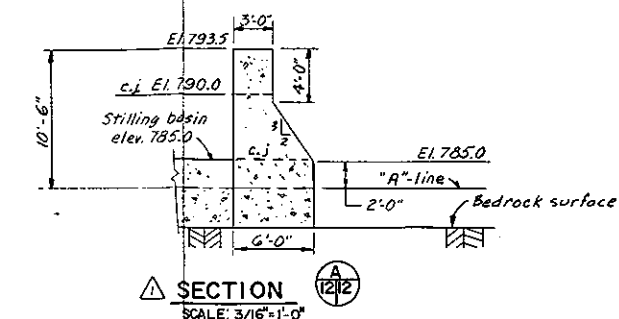
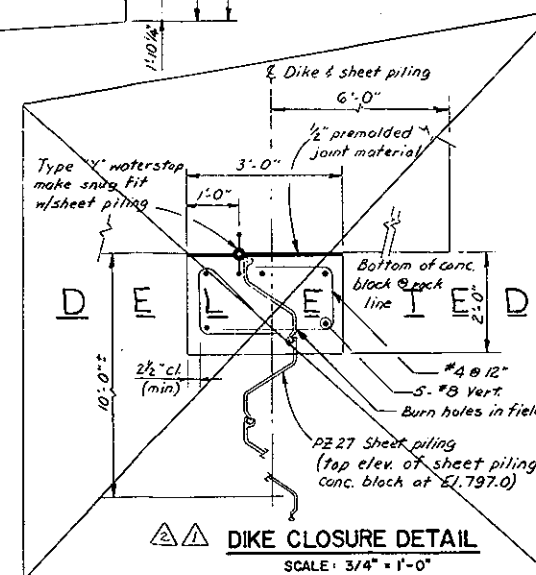
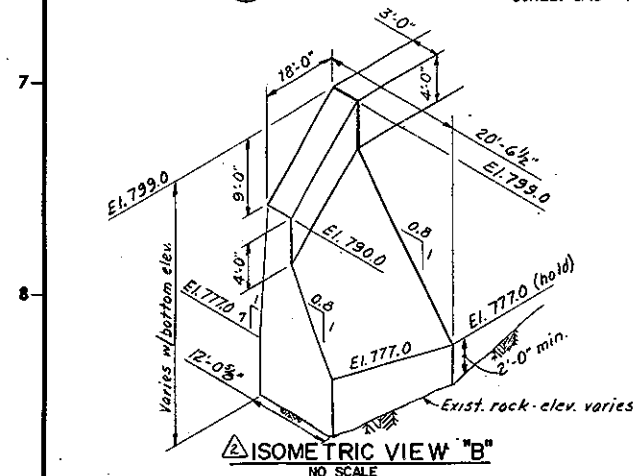
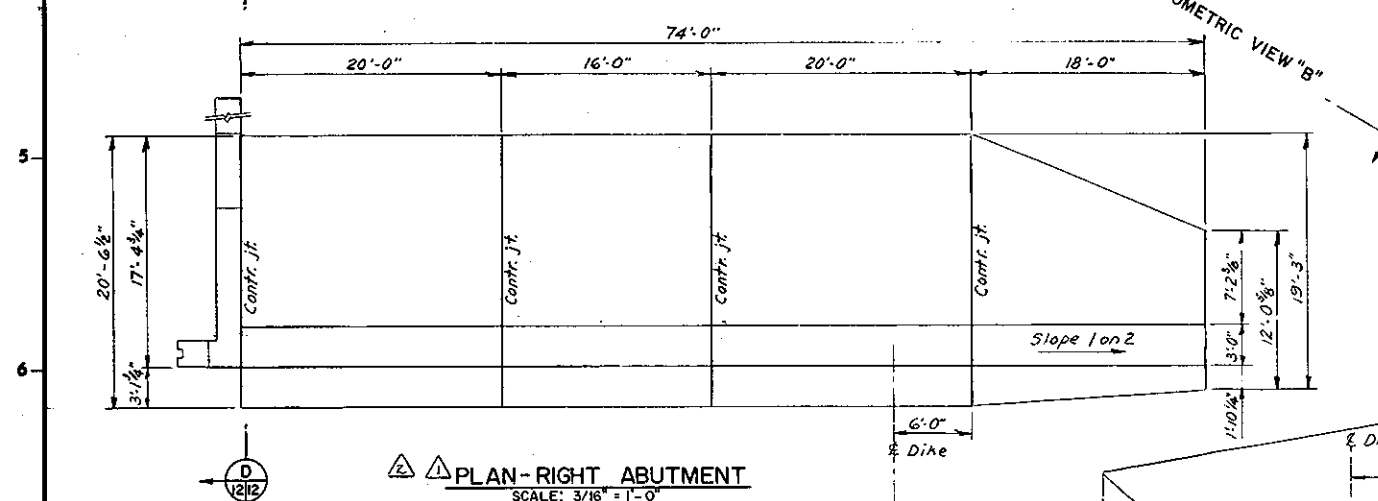
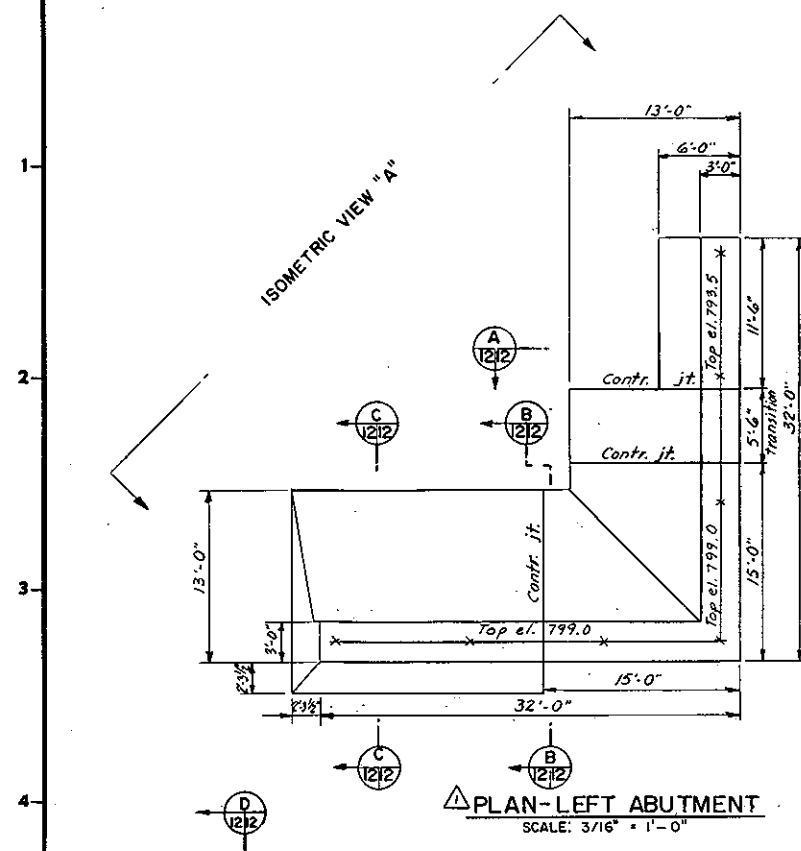


GRAPHIC SCALES
1" = 5' 0" 10' 20'
1" = 10' 0" 10' 20'
As Built Drawing
Contract No. DACW 33-85-0-0053

5/3/91 Final field corrections		
3/5/86 Section Added, Revised Notes & Section		
9/3/85 Sections revised (Am. #1)		
REVISION	DATE	DESCRIPTION
DEPARTMENT OF THE ARMY NEW ENGLAND DIVISION CORPS OF ENGINEERS WALTHAM, MASS.		
WATER RESOURCES DEVELOPMENT PROJECT KEENE, NEW HAMPSHIRE LOCAL PROTECTION PROJECT THREE MILE SWAMP DAM SECTIONS NO. 3		
BEAVER BROOK APPROVED: <i>[Signature]</i> DATE: AUG. 1985		NEW HAMPSHIRE SCALE: AS SHOWN SPEC. NO. DACW33-85-0-0047 DRAWING NUMBER KEE - 1 SHEET 9



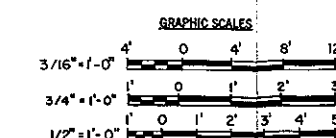




Note: For clarity, exist. ground & fill not shown on abutment sections.

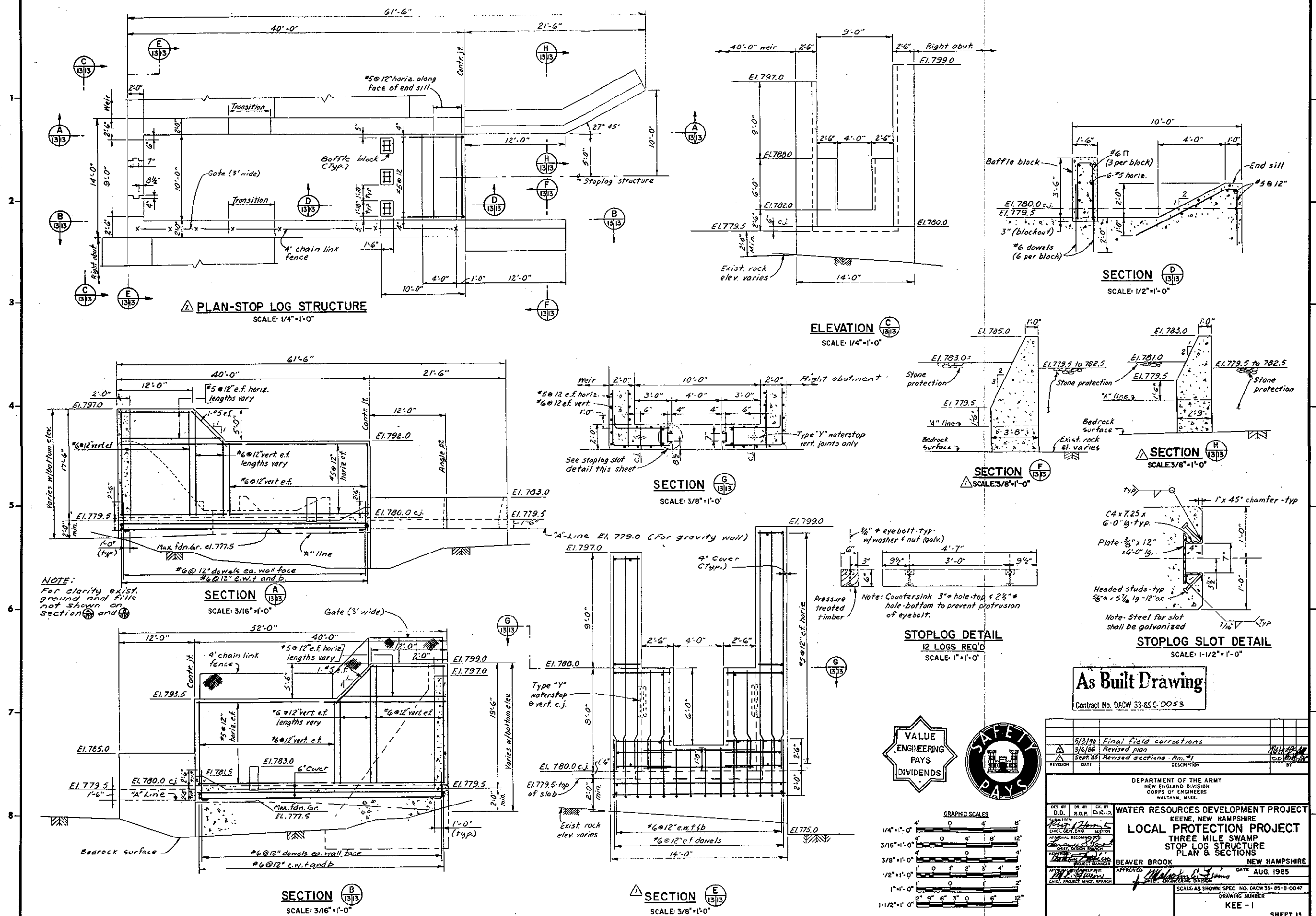
As Built Drawing

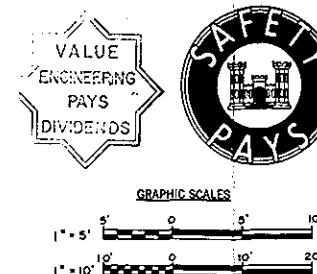
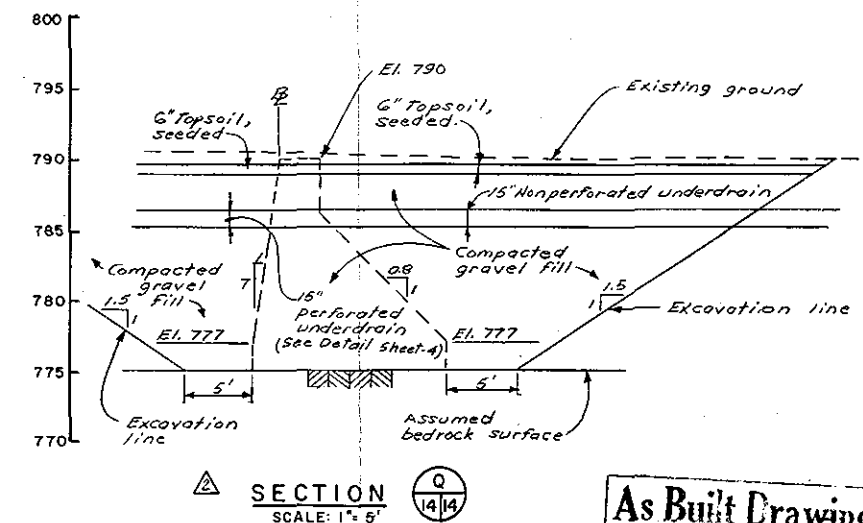
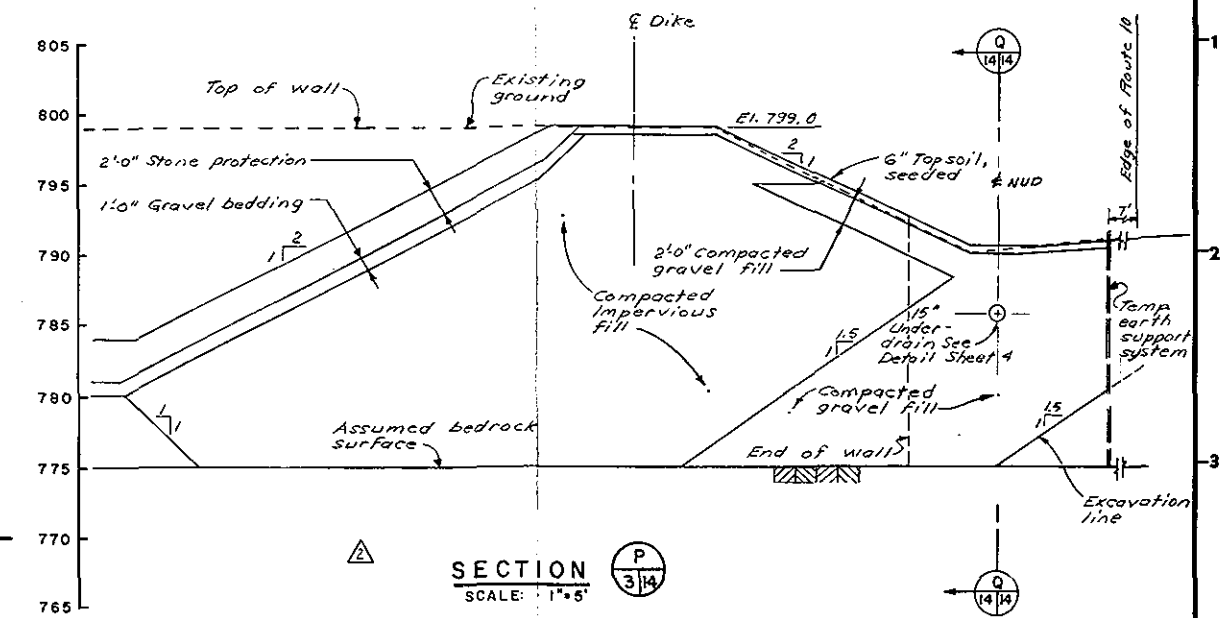
Project No. DACW 33-85C-0053



REVISION	DATE	DESCRIPTION	BY
1	6/3/90	Final field corrections	
2	3/6/86	Revised plan, isometric, section; deleted detail	
3	Sept 85	Revised Plans, isometric, detail sections, added note - Amended	

DEPARTMENT OF THE ARMY NEW ENGLAND DIVISION CORPS OF ENGINEERS WALTHAM, MASS.	
SUBMITTER D.D. R.D.P. D.R.D.	WATER RESOURCES DEVELOPMENT PROJECT KEENE, NEW HAMPSHIRE LOCAL PROTECTION PROJECT THREE MILE SWAMP LEFT & RIGHT ABUTMENTS PLANS & SECTIONS BEAVER BROOK NEW HAMPSHIRE
APPROVED [Signature] CHIEF, PROJECT BRANCH	DATE AUG. 1985 SPEC. NO. DACW33-85-B-0047 DRAWING NUMBER KEE - I SHEET 12



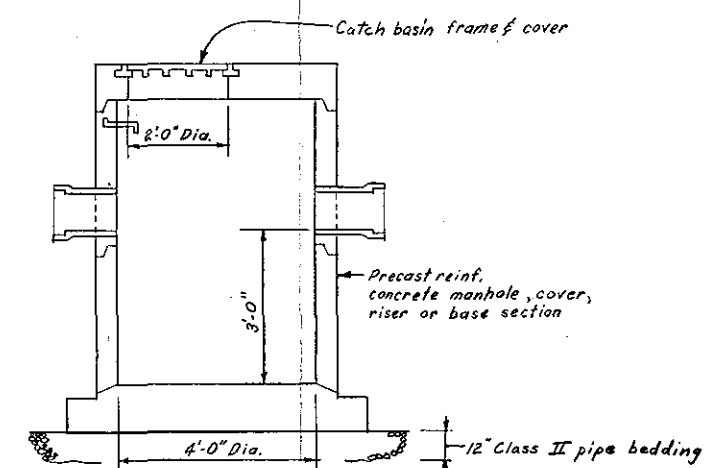
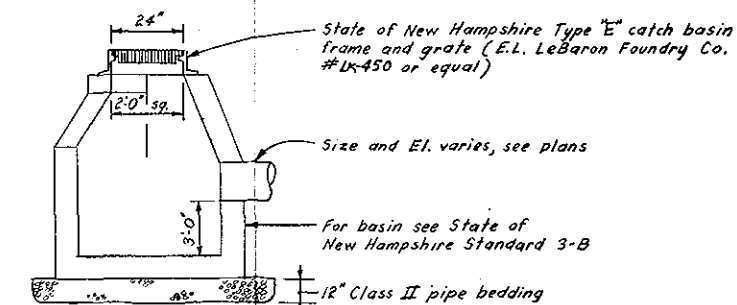
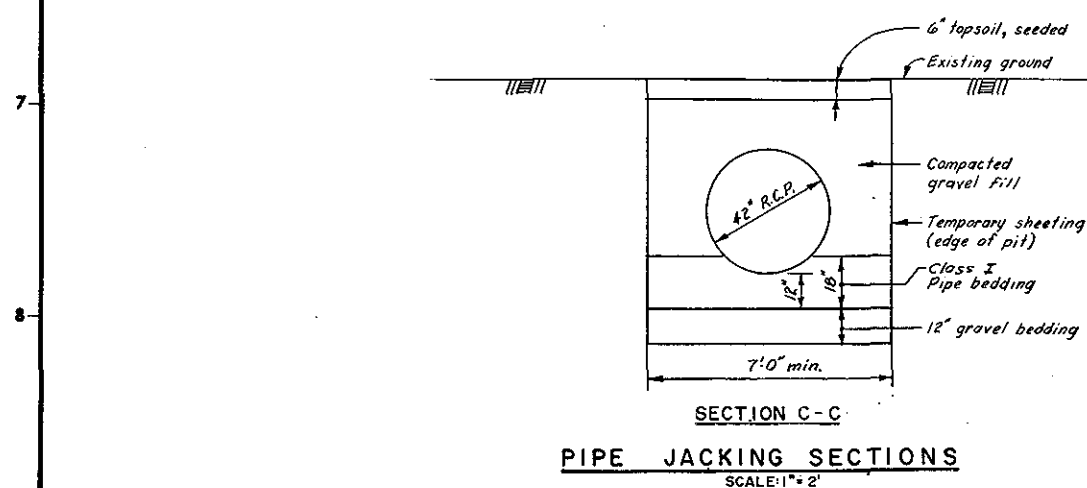
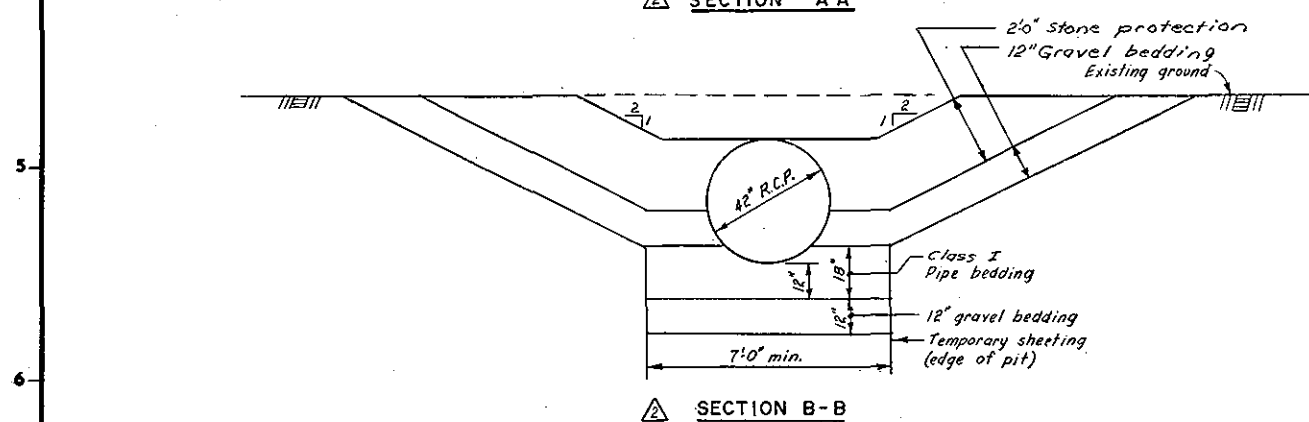
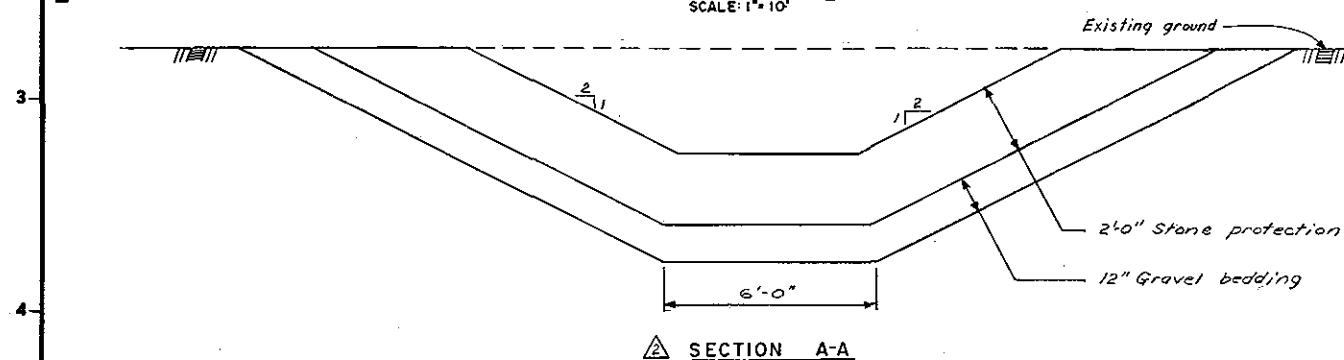
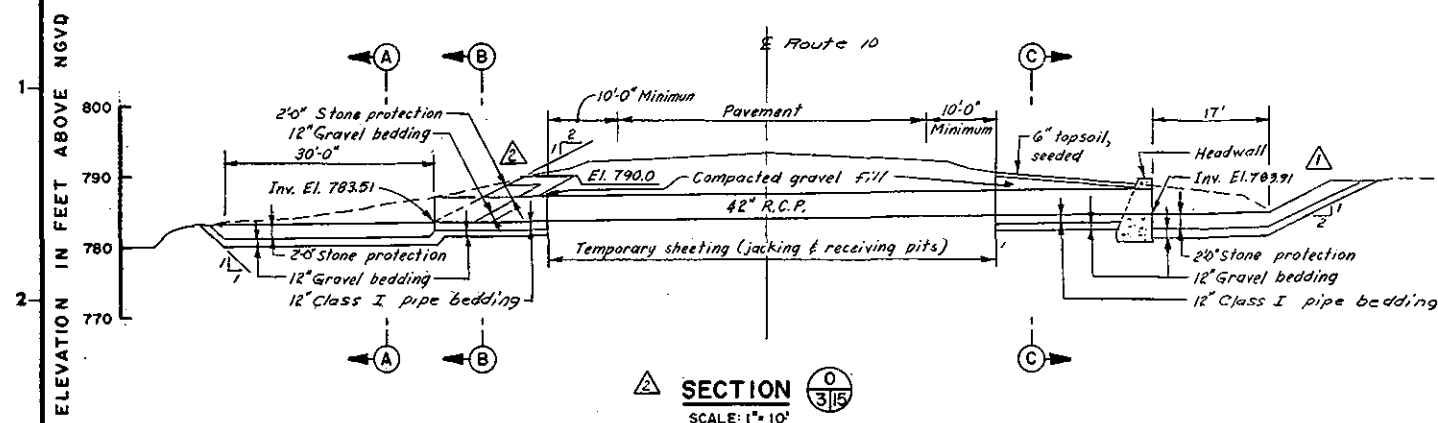


△ NOTES:

1. Placement of fills for Dike "A" shall stop at Sta. 0+50 as shown, until the stage 2a coffee dam is constructed and dewatered.
2. See Section, Earth Fills for sequence of construction and for special placement and compaction requirements for the dike closure section.
3. The slope of the end section at Sta. 0+50 shall be constructed no steeper than 1 on 3, as shown.

As Built Drawing

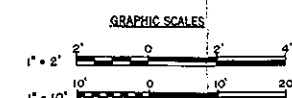
[illegible]



CATCH BASIN TYPE 2 DETAIL
N.T.S.

As Built Drawing

Contract No. DACW 33-85C-0053

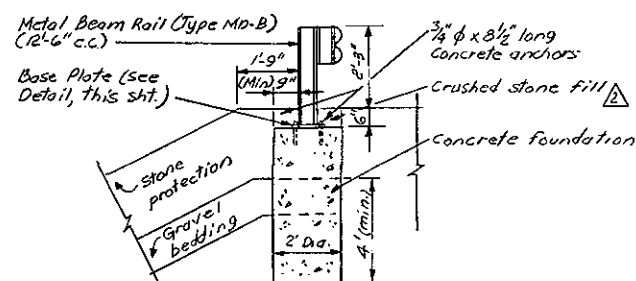


DES. BY MAD, S.W.K.	CHK. BY MAD	DATE 6/3/90	DESCRIPTION Final field corrections
APPROVAL [Signature]	DATE 3/6/86	DESCRIPTION Revised Sections & Notes	
APPROVAL [Signature]	DATE 9/3/85	DESCRIPTION Details revised (Am. #1)	

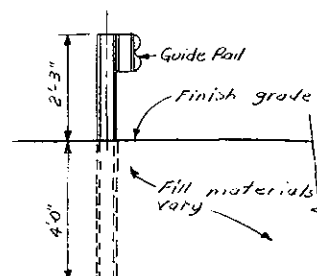
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

WATER RESOURCES DEVELOPMENT PROJECT
KEENE, NEW HAMPSHIRE
LOCAL PROTECTION PROJECT
THREE MILE SWAMP
DRAINAGE SECTIONS

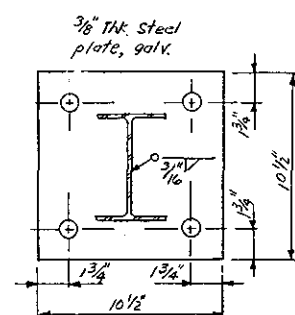
BEAVER BROOK
APPROVED: [Signature] DATE: AUG. 1985
SCALE: AS SHOWN SPEC. NO. DACW33-85-B-0047
DRAWING NUMBER
KEE - I
SHEET 15



GUIDE RAIL IN STONE PROTECTION



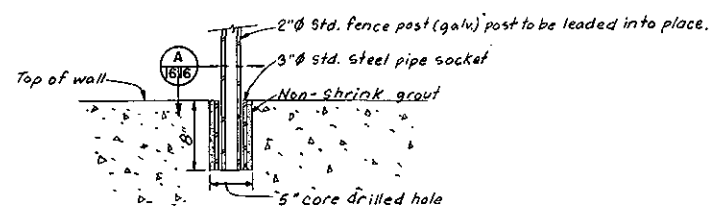
GUIDE RAIL IN FILL



BASE PLATE DETAIL

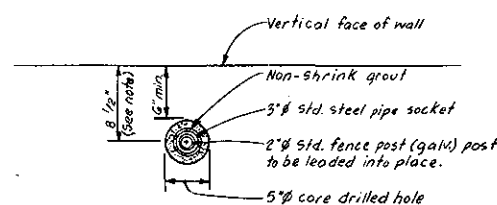
GUIDE RAIL DETAILS

N.T.S.



DETAIL-SOCKET FOR CHAIN LINK FENCE

N.T.S.

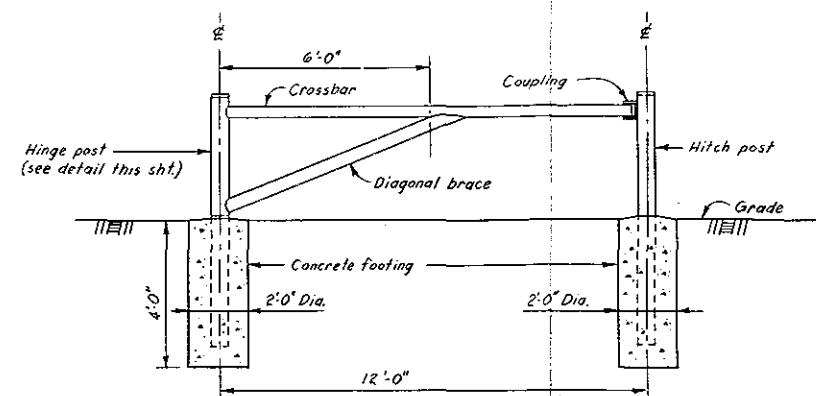


SECTION A-1616

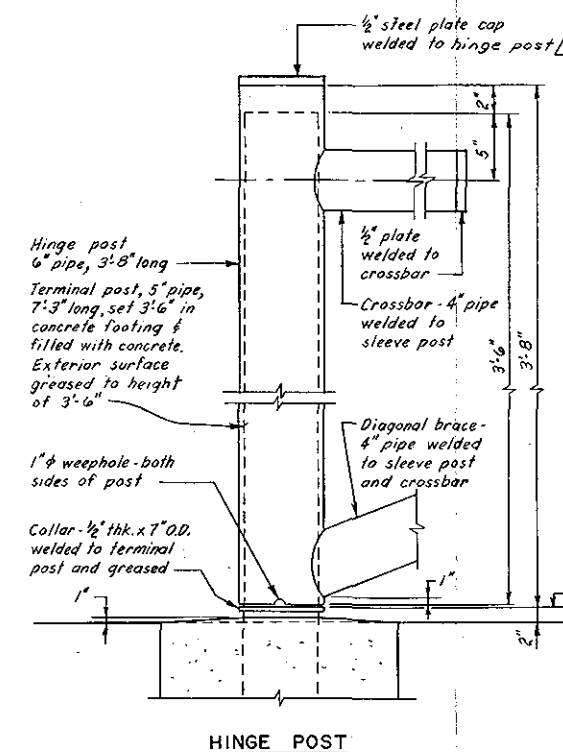
N.T.S.

NOTE:

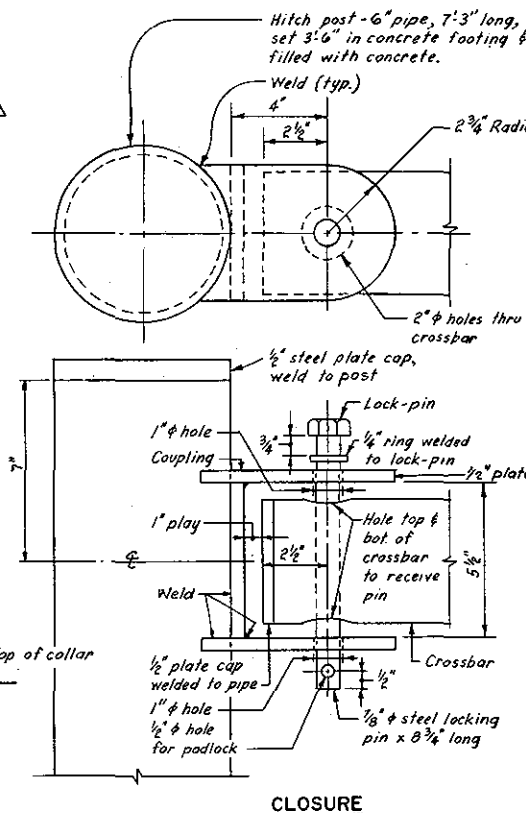
Center fence posts along 2'-wide stoplog wall adjacent to right abutment. (see plan)



GATE



HINGE POST



CLOSURE

SINGLE-LEAF GATE DETAILS

NOT TO SCALE

As Built Drawing

Contract No. DACW 33-85-C-0053



GRAPHIC SCALES

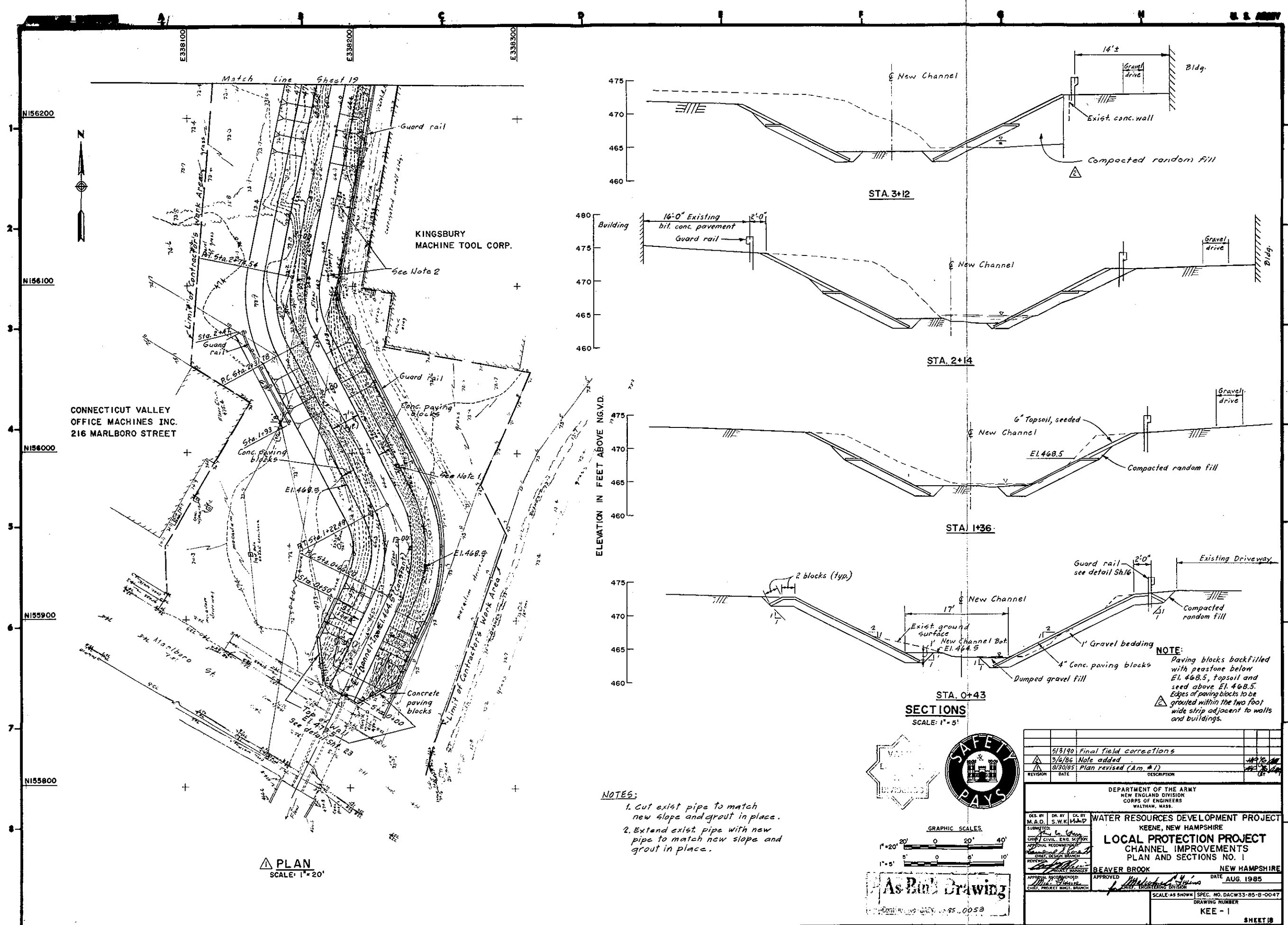
REVISION	DATE	DESCRIPTION
1	5/3/90	Final field corrections
2	3/6/86	Notes revised
3	6/30/85	Details revised (Am. #1)

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

WATER RESOURCES DEVELOPMENT PROJECT
KEENE, NEW HAMPSHIRE
LOCAL PROTECTION PROJECT
THREE MILE SWAMP
MISCELLANEOUS DETAILS

BEAVER BROOK NEW HAMPSHIRE
APPROVED: *[Signature]* DATE: AUG. 1985
CHIEF, ENGINEERING DIVISION

SCALE AS SHOWN SPEC. NO. DACW33-85-B-0047
DRAWING NUMBER
KEE - I
SHEET 16



CONNECTICUT VALLEY
OFFICE MACHINES INC.
216 MARLBORO STREET

KINGSBURY
MACHINE TOOL CORP.

PLAN
SCALE: 1" = 20'

- NOTES:
1. Cut exist pipe to match new slope and grout in place.
 2. Extend exist. pipe with new pipe to match new slope and grout in place.

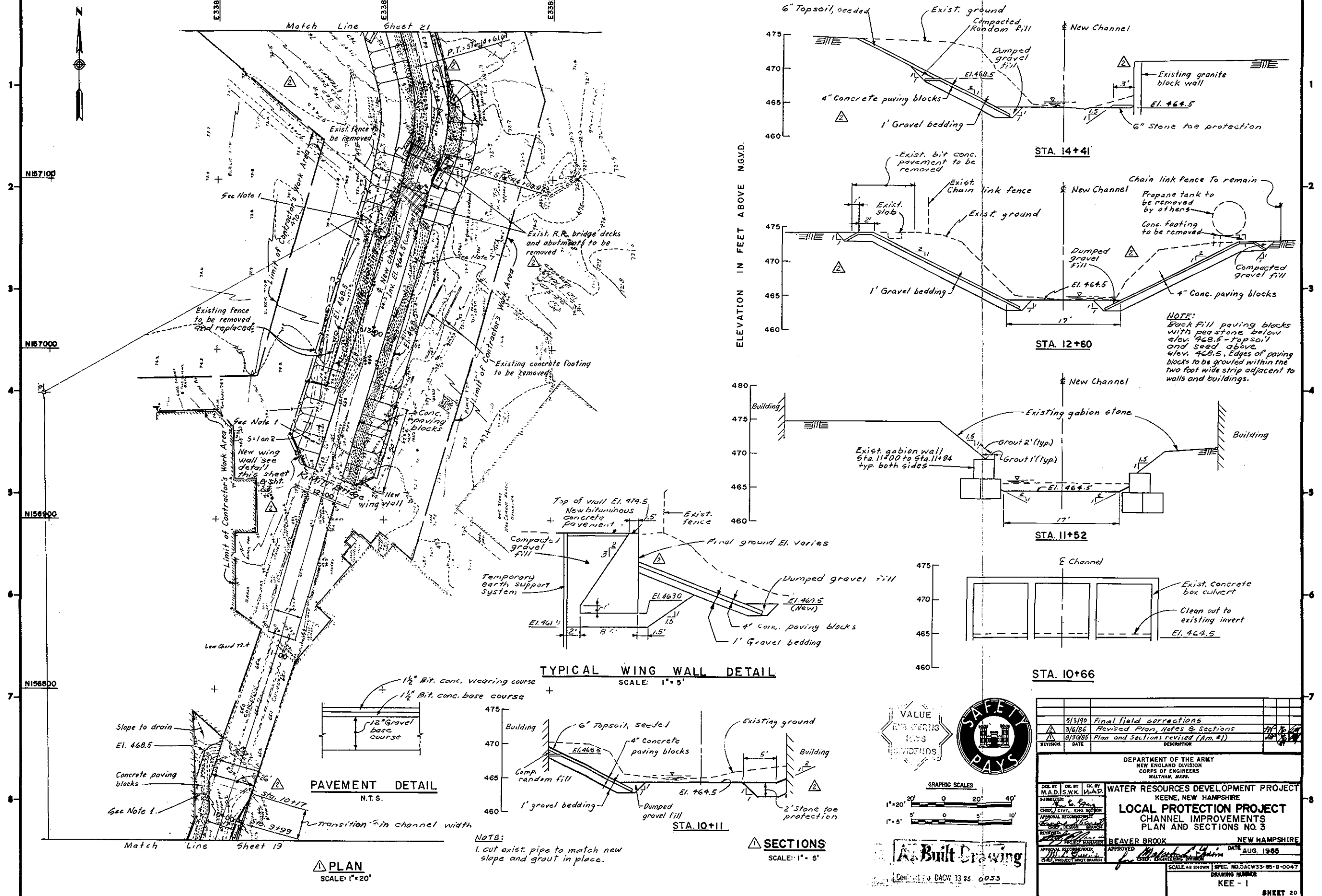


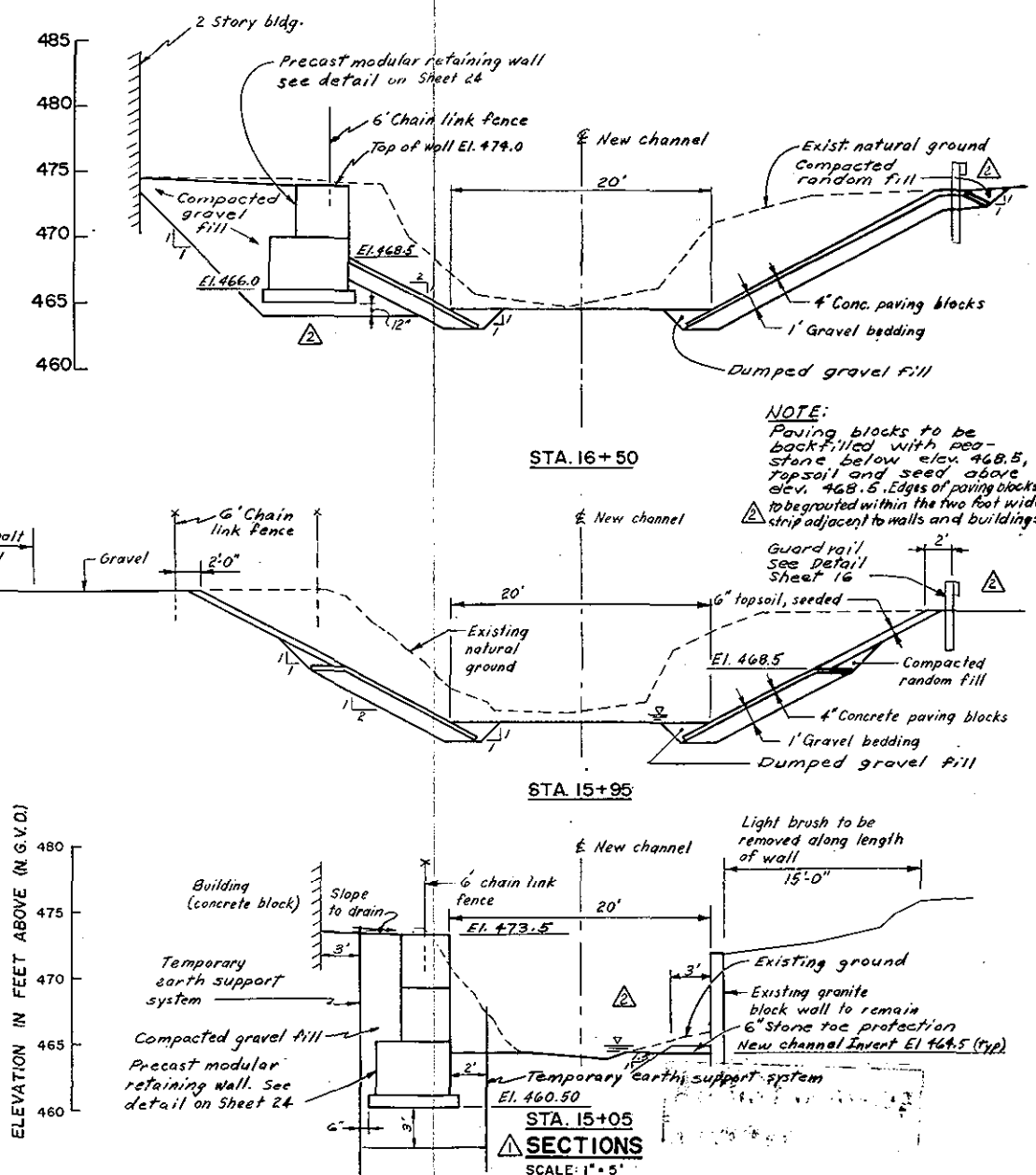
GRAPHIC SCALES
1" = 20' 0" 20' 40'
1" = 5' 0" 5' 10'

As Built Drawing

5/31/90 Final field corrections		
3/6/86 Note added		
3/30/85 Plan revised (Am. #1)		
REVISION	DATE	DESCRIPTION
DEPARTMENT OF THE ARMY NEW ENGLAND DIVISION CORPS OF ENGINEERS WALTHAM, MASS.		
WATER RESOURCES DEVELOPMENT PROJECT KEENE, NEW HAMPSHIRE		
LOCAL PROTECTION PROJECT CHANNEL IMPROVEMENTS PLAN AND SECTIONS NO. 1		
BEAVER BROOK		NEW HAMPSHIRE
APPROVED		DATE AUG. 1985
SCALE: AS SHOWN		SPEC. NO. DACW33-85-8-0047
DRAWING NUMBER		KEE - 1
		SHEET 18







1. Work on properties at the Findings Inc. and 163 Water Street shall be limited to 90 consecutive calendar days. A 30 day written notice will be required prior to start of work.

New precast
modular wall "B"
Top El. 473.5.
see sheet 24

The block contains two logos. On the left is a diamond-shaped logo with the text "VALUE ENGINEERING PAYS" inside. On the right is a circular logo with the text "SAFETY PAYS" around the perimeter and an illustration of a factory or industrial building in the center.

GRAPHIC SCALES

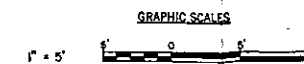
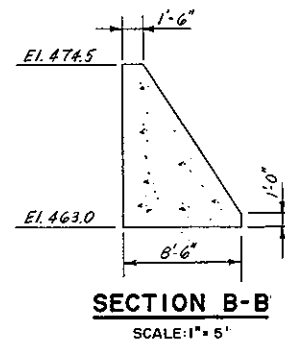
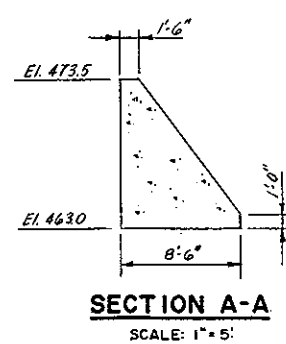
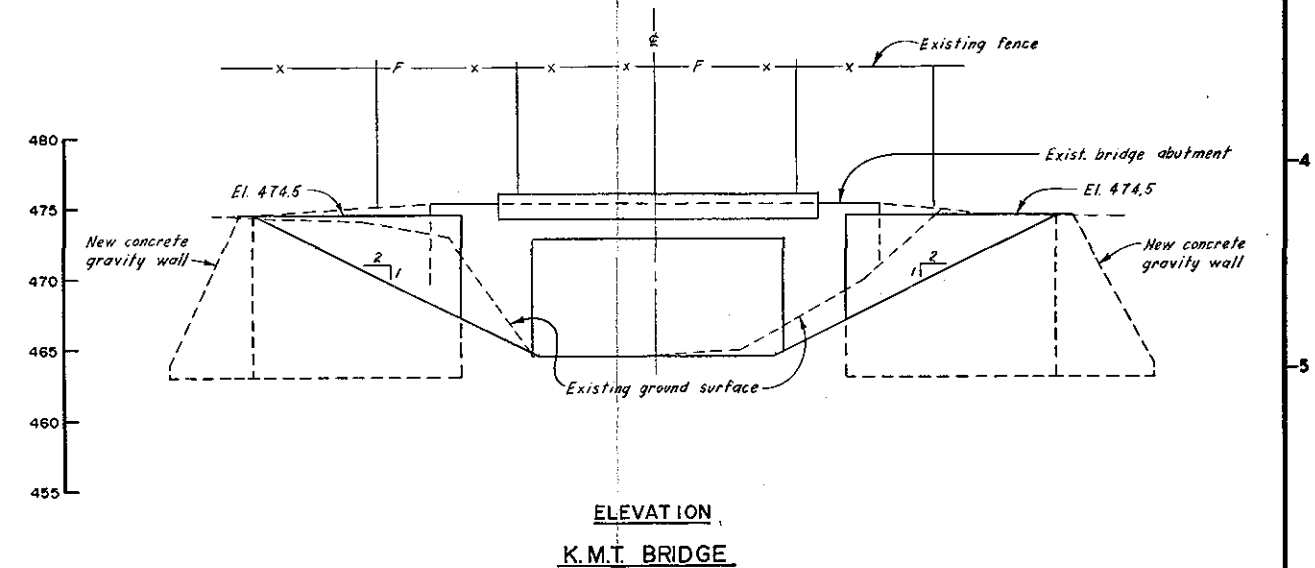
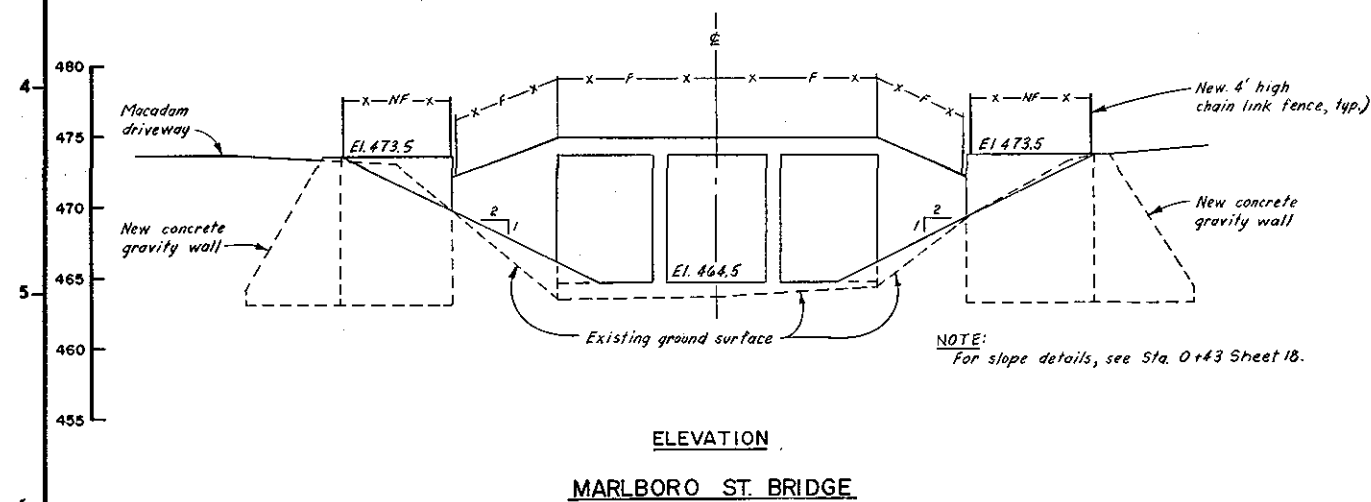
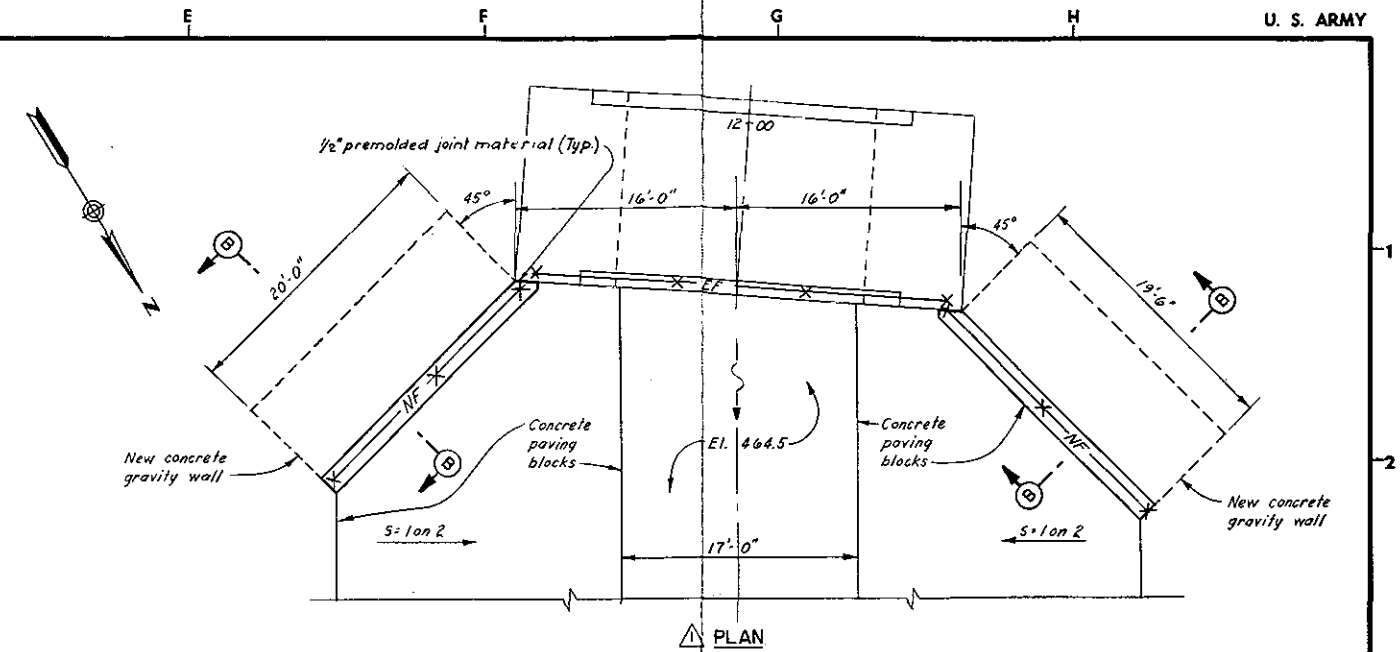
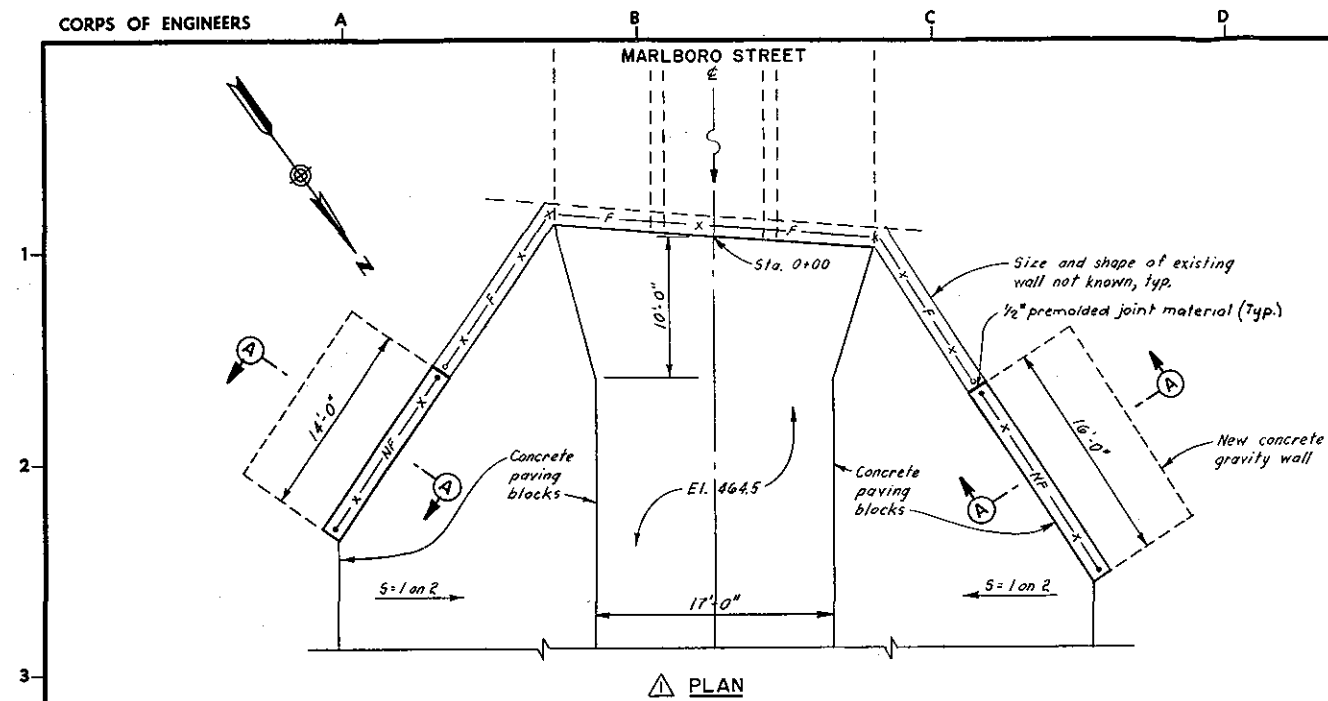
1" = 20'

1" = 5'

As Built Drawing

CONT. NO. FLOW 23-852.0053

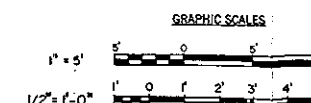
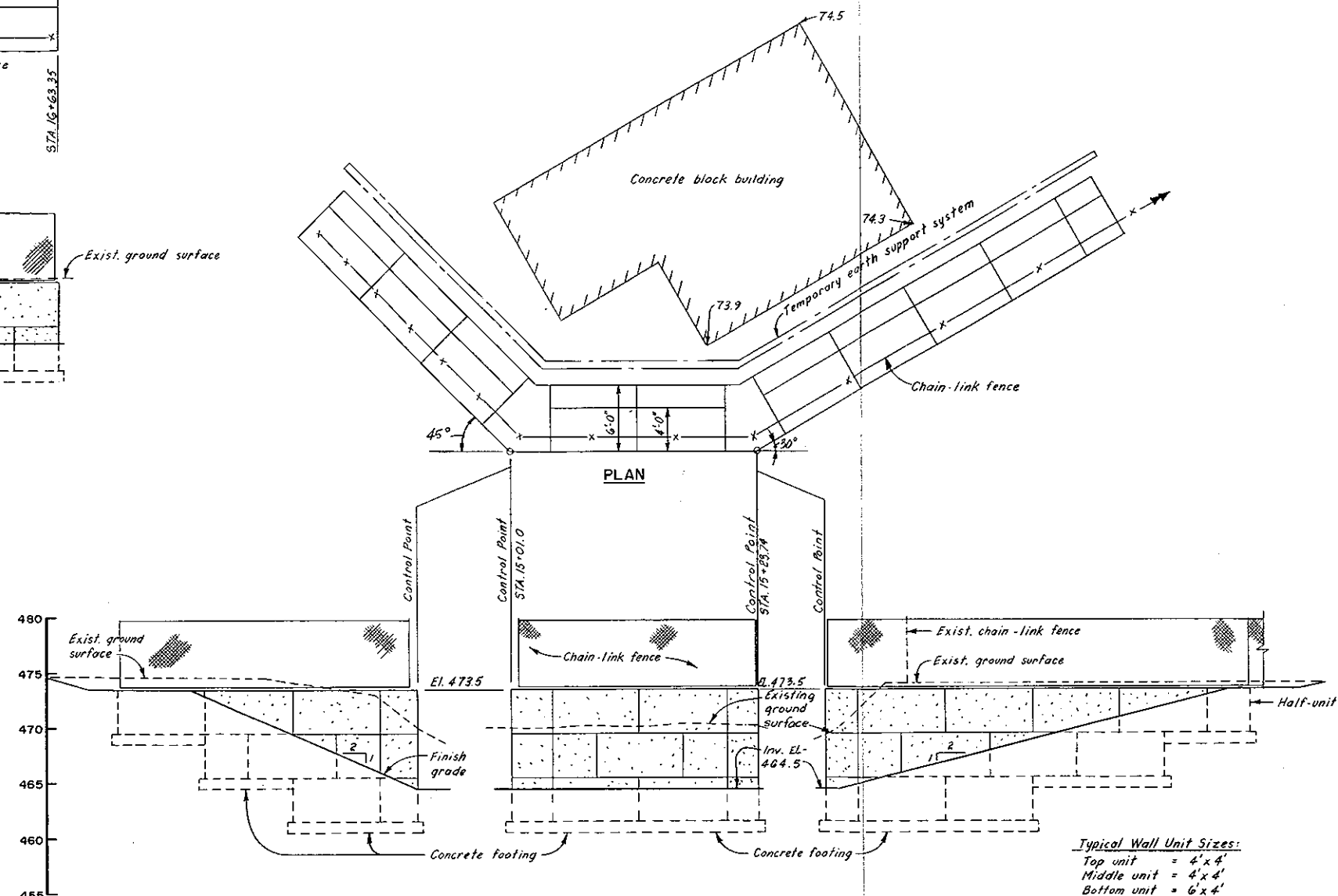
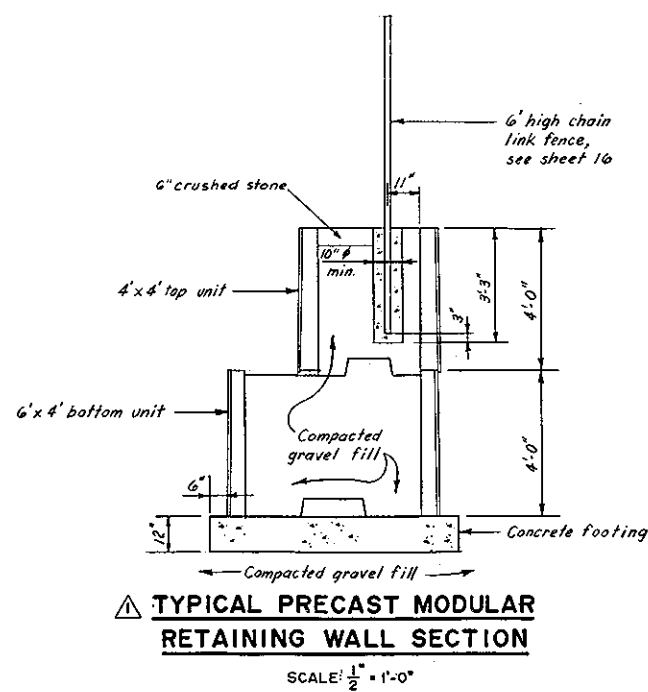
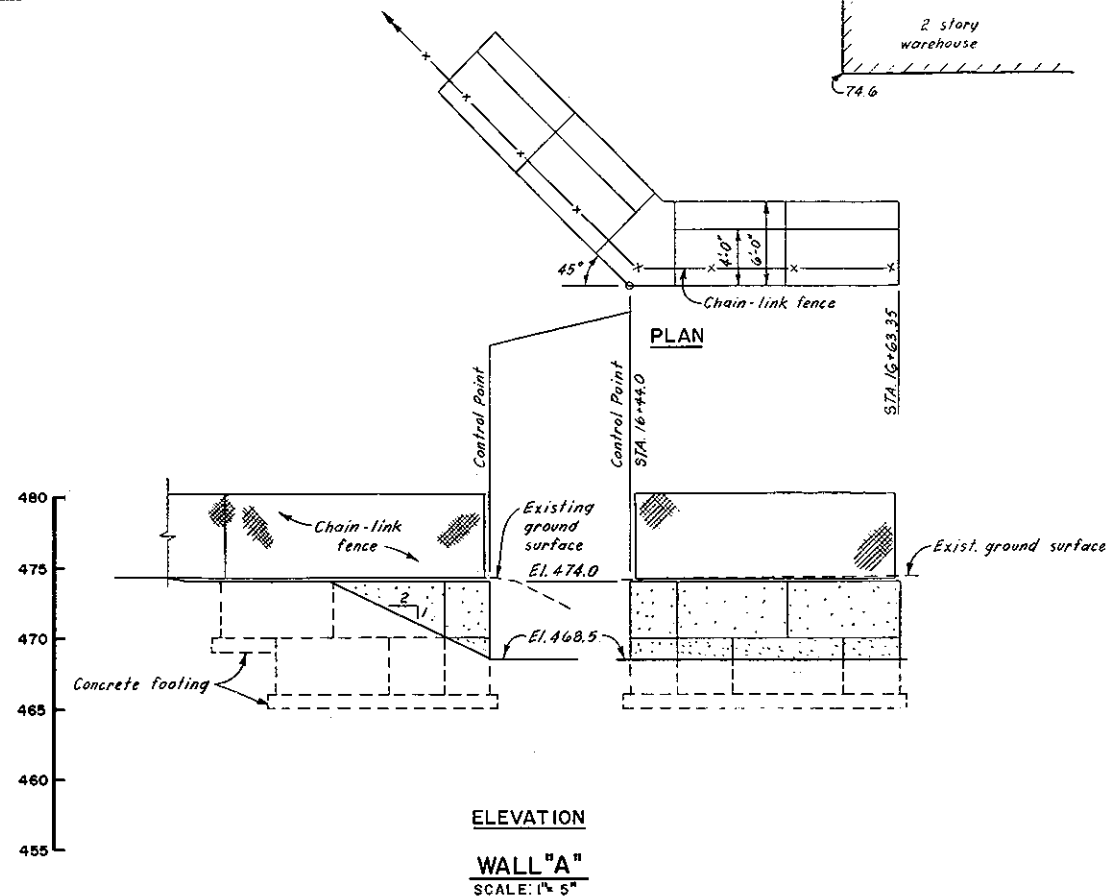
[illegible]



As Built Drawing

Contract No. DAWC 85-0053

DES. BY M.A.D.	DR. BY S.W.K.	CR. BY M.A.D.	WATER RESOURCES DEVELOPMENT PROJECT KEENE, NEW HAMPSHIRE	
SUBMITTED 10/1/85			LOCAL PROTECTION PROJECT CHANNEL IMPROVEMENTS WING WALLS	
APPROVAL RECOMMENDATION 10/1/85			BEAVER BROOK NEW HAMPSHIRE	
REVISION 10/1/85			DATE AUG. 1985	
APPROVED 10/1/85			SCALE: AS SHOWN SPEC. NO. DACW33-85-B-0047	
DRAWING NUMBER KEE - 1			SHEET 23	



DES. BY M.A.D.	DR. BY S.W.K.	CL. BY J.W.D.	6/3/90 Final field corrections
SUBMITTED Yes	CHIEF CIVIL ENG. SECTION	CHIEF DESIGN BRANCH	CHIEF PROJECT MGMT BRANCH
APPROVAL RECOMMENDATION [Signature]	APPROVED [Signature]	DATE AUG. 1985	
DEPARTMENT OF THE ARMY NEW ENGLAND DIVISION CORPS OF ENGINEERS WALTHAM, MASS.			
WATER RESOURCES DEVELOPMENT PROJECT KEENE, NEW HAMPSHIRE LOCAL PROTECTION PROJECT. CHANNEL IMPROVEMENTS PRECAST MODULAR RETAINING WALLS BEAVER BROOK NEW HAMPSHIRE			
SCALE: AS SHOWN		SPEC. NO. DACW 33-85-B-0047	DRAWING NUMBER KEE - 1
		SHEET 24	